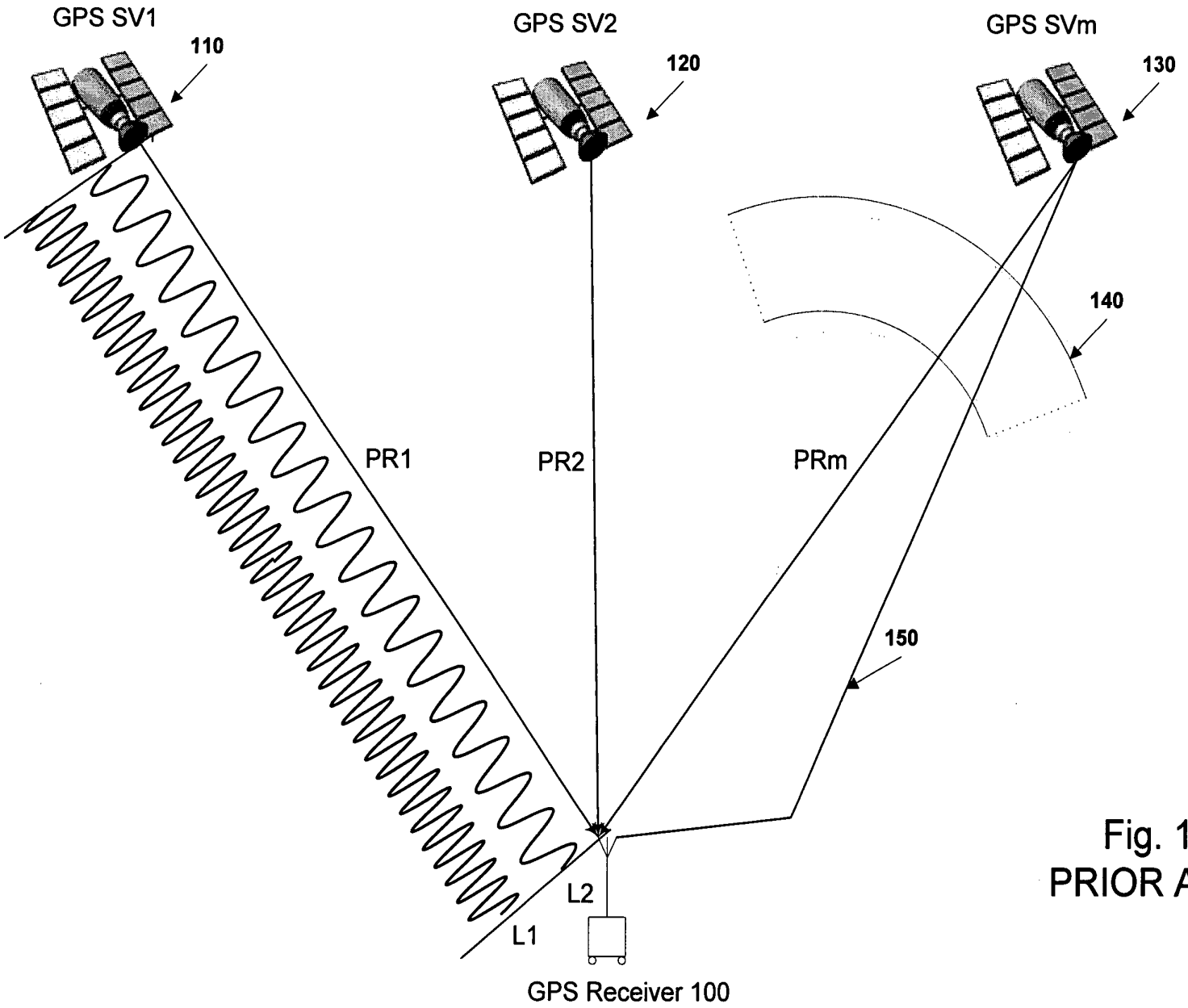


Fig. 1
PRIOR ART

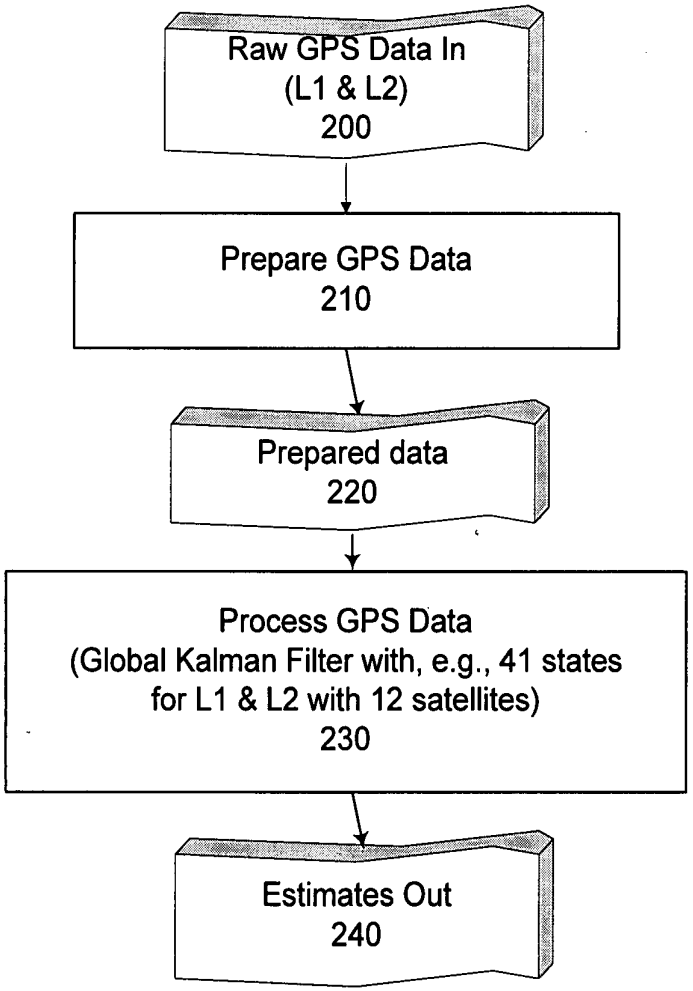


Fig. 2
PRIOR ART

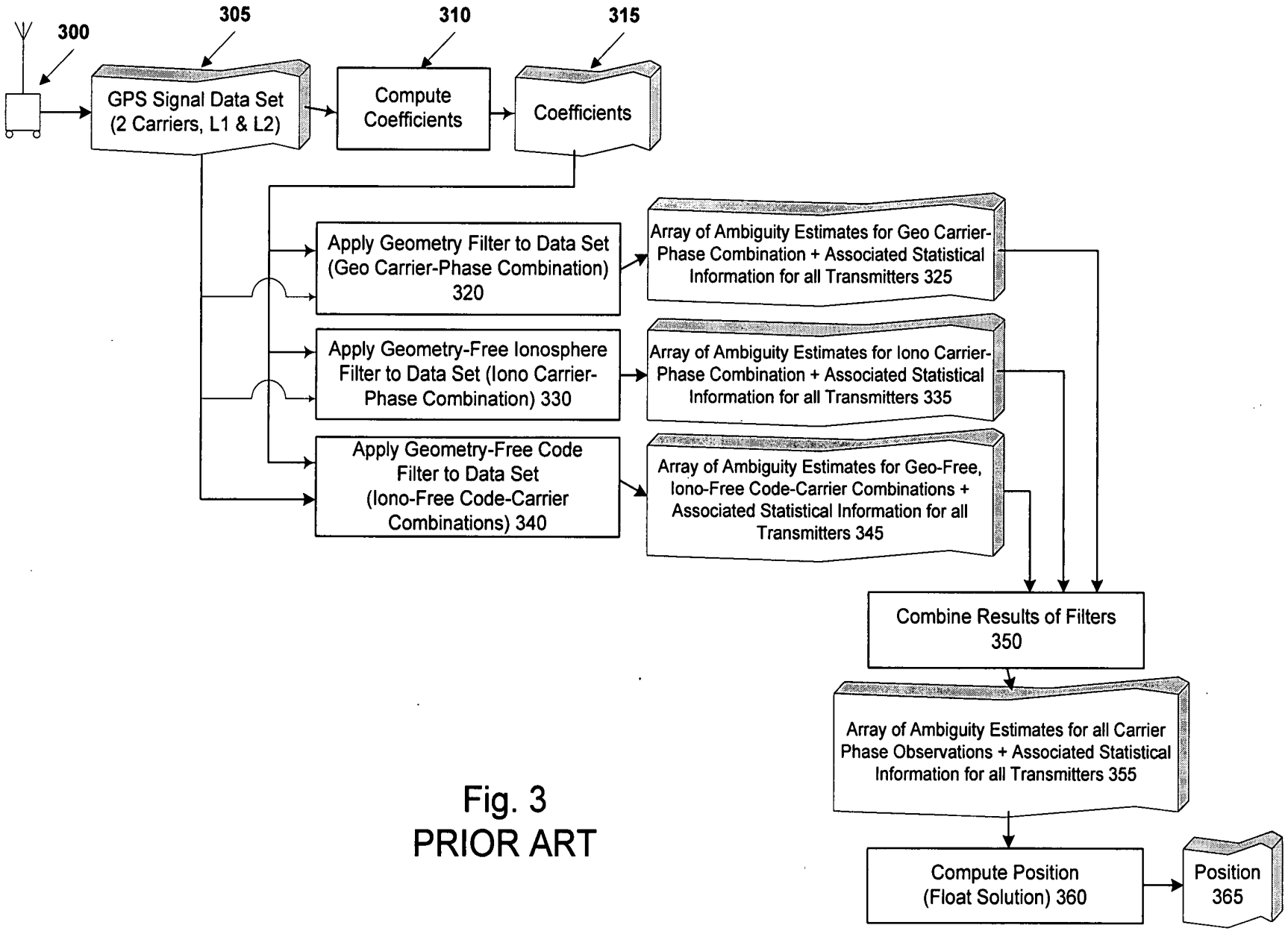


Fig. 3
PRIOR ART

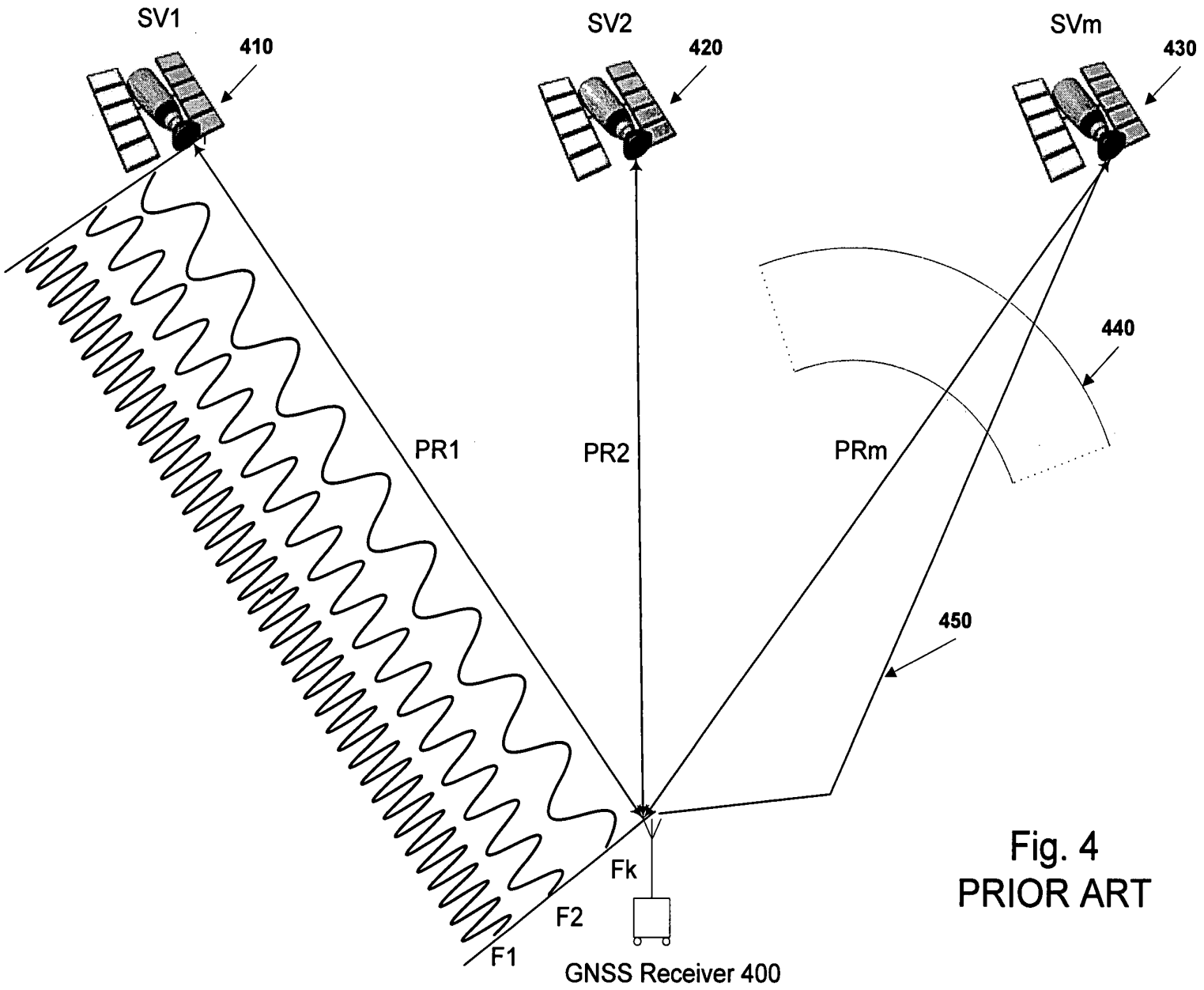
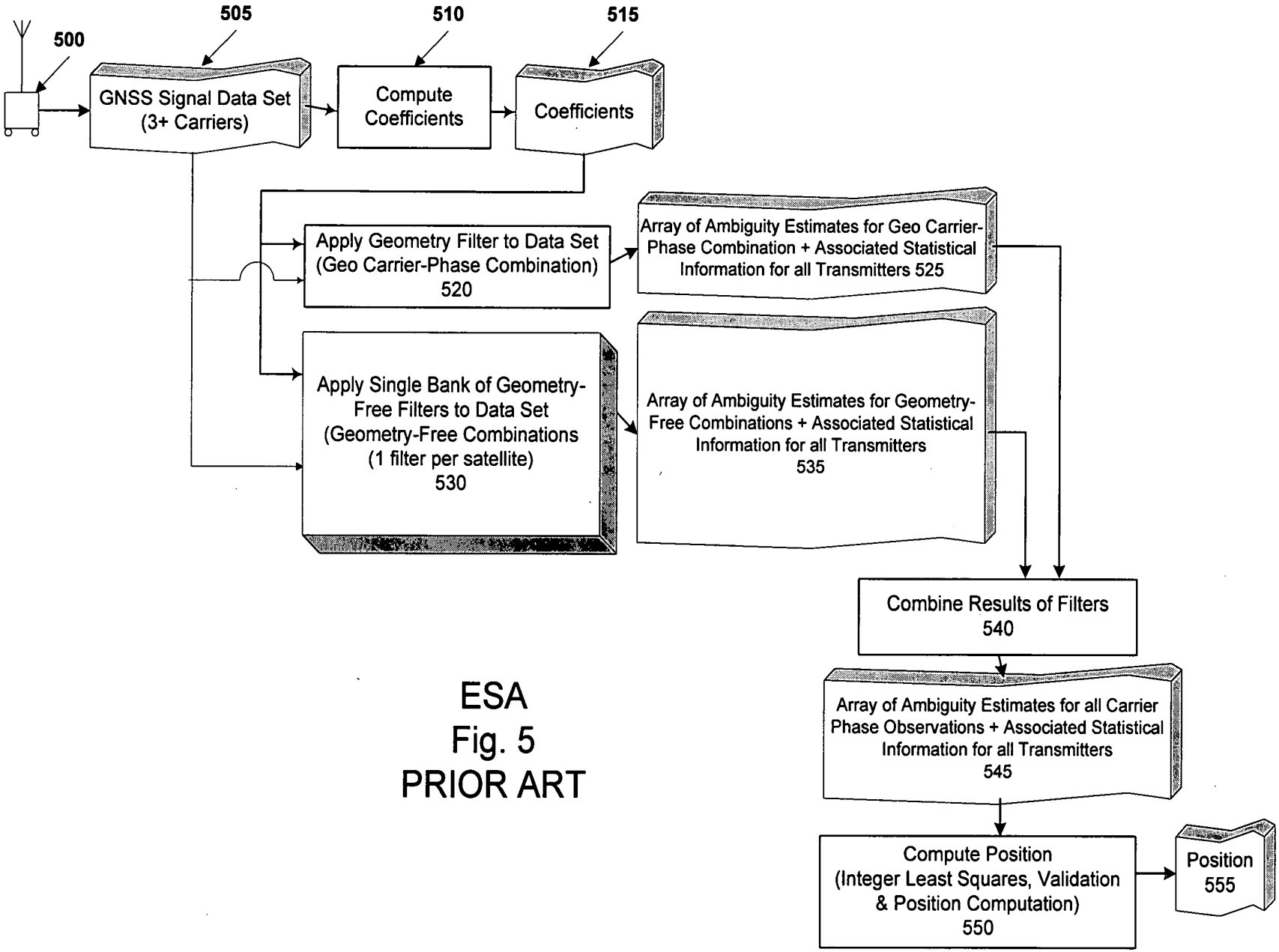


Fig. 4
PRIOR ART



ESA
Fig. 5
PRIOR ART

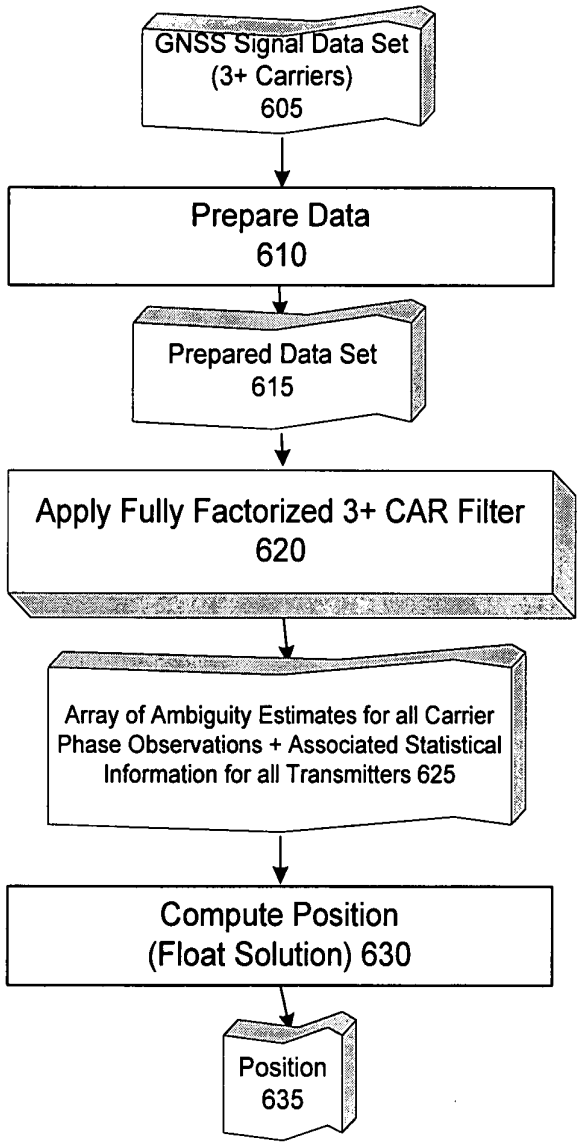

GNSS Signal Data Set
(3+ Carriers)
605
Prepare Data
610
Prepared Data Set
615
Apply Fully Factorized 3+ CAR Filter
620
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information for all Transmitters 625
Compute Position
(Float Solution) 630
Position
635

Fig. 6

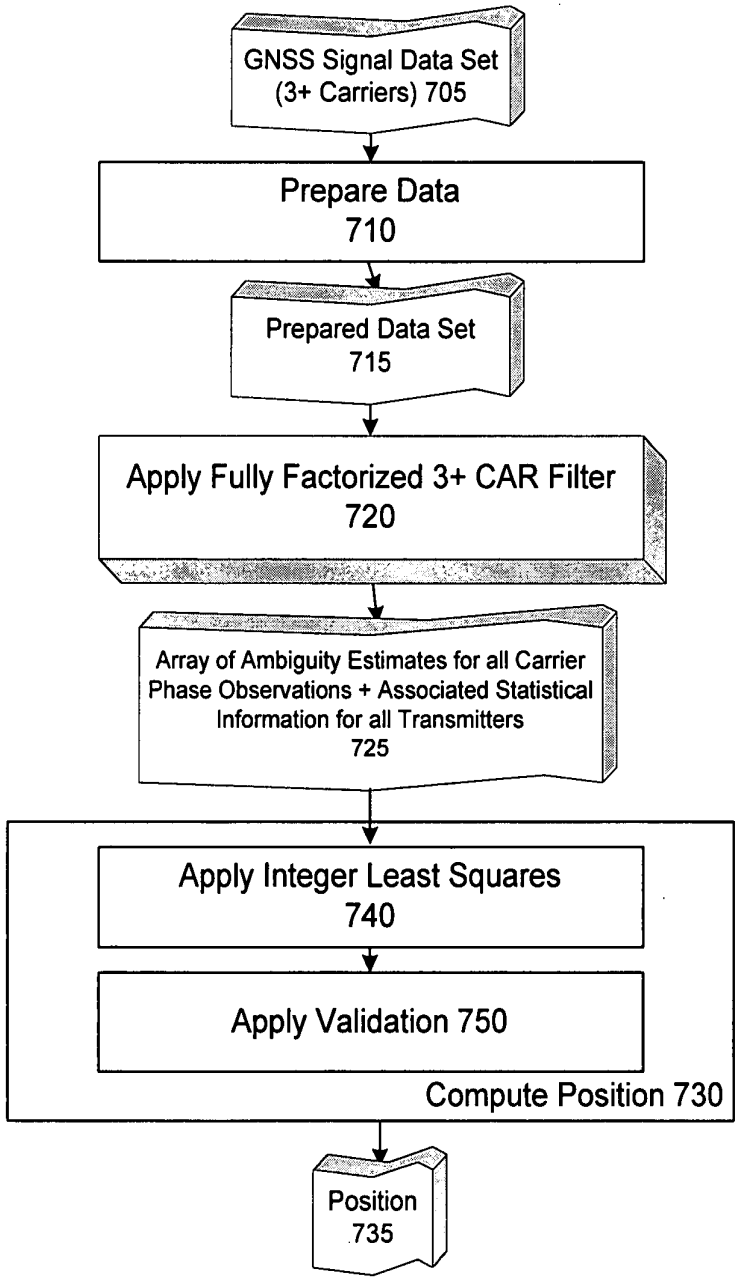

GNSS Signal Data Set (3+ Carriers) 705
Prepare Data 710
Prepared Data Set 715
Apply Fully Factorized 3+ CAR Filter 720
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information for all Transmitters 725
Apply Integer Least Squares 740
Apply Validation 750
Compute Position 730
Position 735

Fig. 7

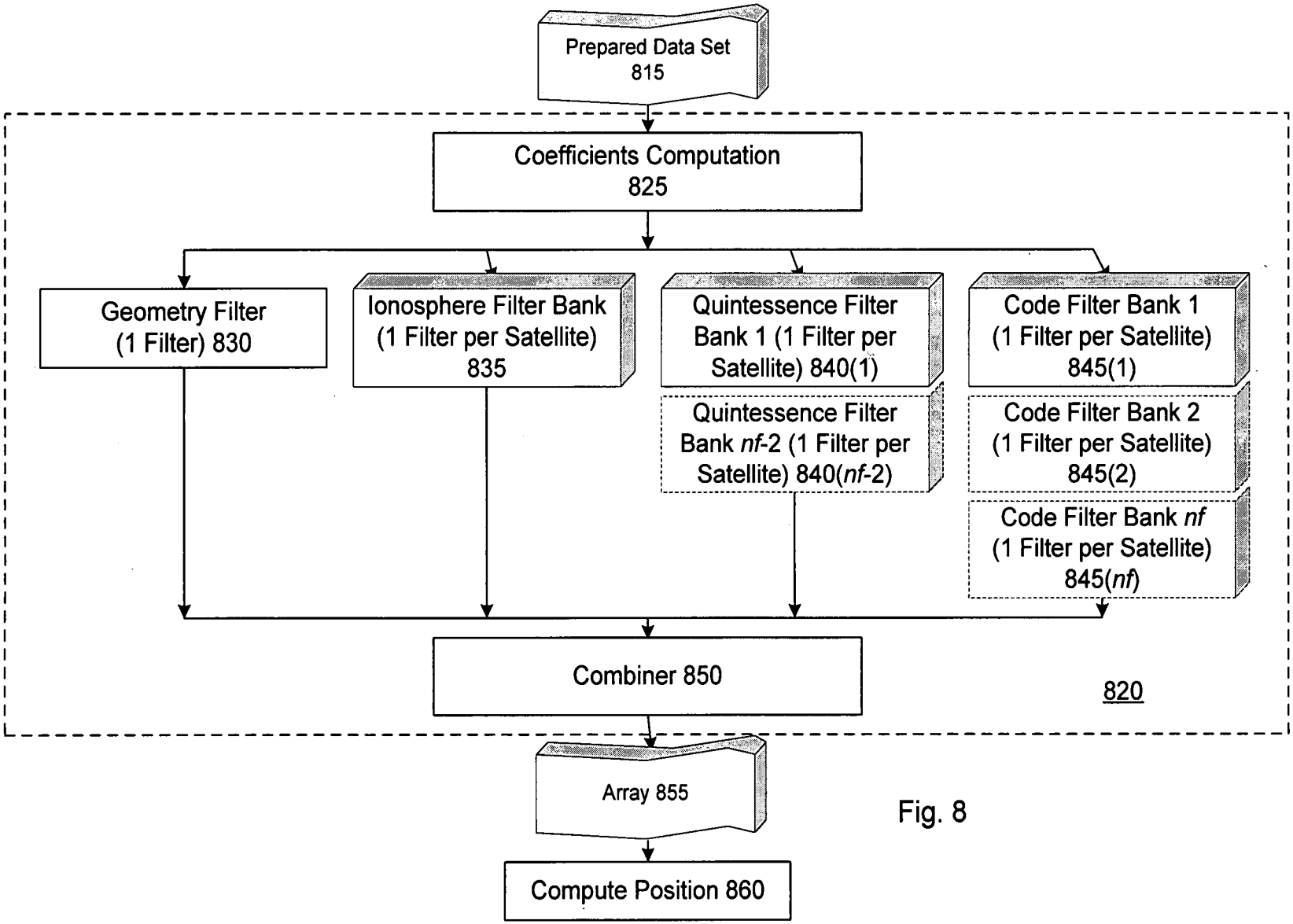

Prepared Data Set
815
Coefficients Computation
825
Geometry Filter
(1 Filter) 830
Ionosphere Filter Bank
(1 Filter per Satellite)
835
Quintessence Filter
Bank 1 (1 Filter per
Satellite) 840(1)
Quintessence Filter
Bank nf-2 (1 Filter per
Satellite) 840(nf-2)
Code Filter Bank 1
(1 Filter per Satellite)
845(1)
Code Filter Bank 2
(1 Filter per Satellite)
845(2)
Code Filter Bank nf
(1 Filter per Satellite)
845(nf)
Combiner 850
820
Array 855
Compute Position 860

Fig. 8

Number of Filters (*ns* filters per Bank)	2 frequencies	3 frequencies	4 frequencies
Geometry	1 Filter	1 Filter	1 Filter
Ionosphere	1 Bank	1 Bank	1 Bank
Quintessence	None	1 Bank	2 Banks
Code	Up to 2 Banks	Up to 3 Banks	Up to 4 Banks

Fig. 9

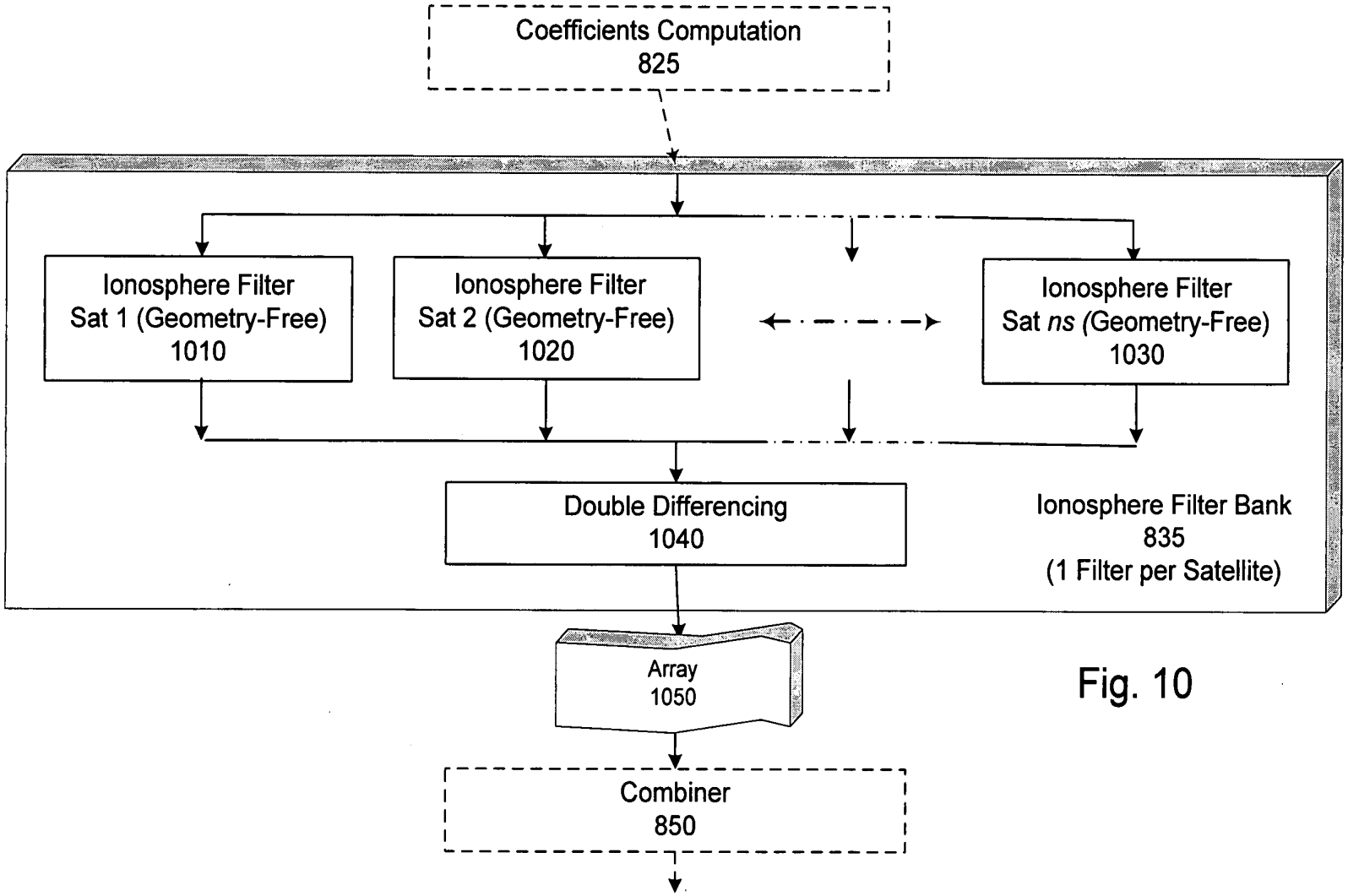

Coefficients Computation
825
Ionosphere Filter
Sat 1 (Geometry-Free)
1010
Ionosphere Filter
Sat 2 (Geometry-Free)
1020
Ionosphere Filter
Sat ns (Geometry-Free)
1030
Double Differencing
1040
Ionosphere Filter Bank
835
(1 Filter per Satellite)
Array
1050
Combiner
850

Fig. 10

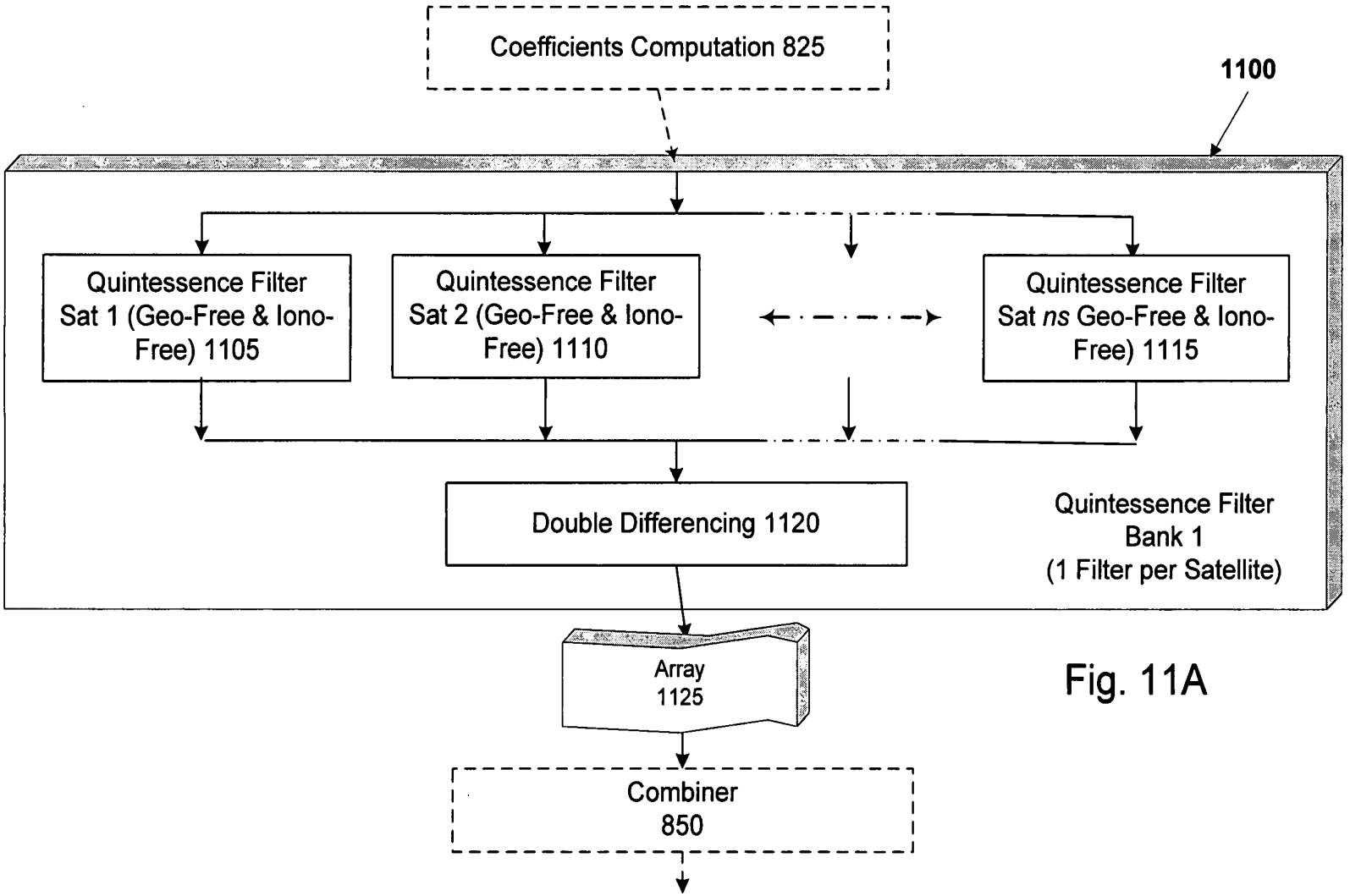

Coefficients Computation 825
1100
Quintessence Filter Sat 1 (Geo-Free & Iono-Free) 1105
Quintessence Filter Sat 2 (Geo-Free & Iono-Free) 1110
Quintessence Filter Sat ns Geo-Free & Iono-Free) 1115
Double Differencing 1120
Quintessence Filter Bank 1 (1 Filter per Satellite)
Array 1125
Combiner 850

Fig. 11A

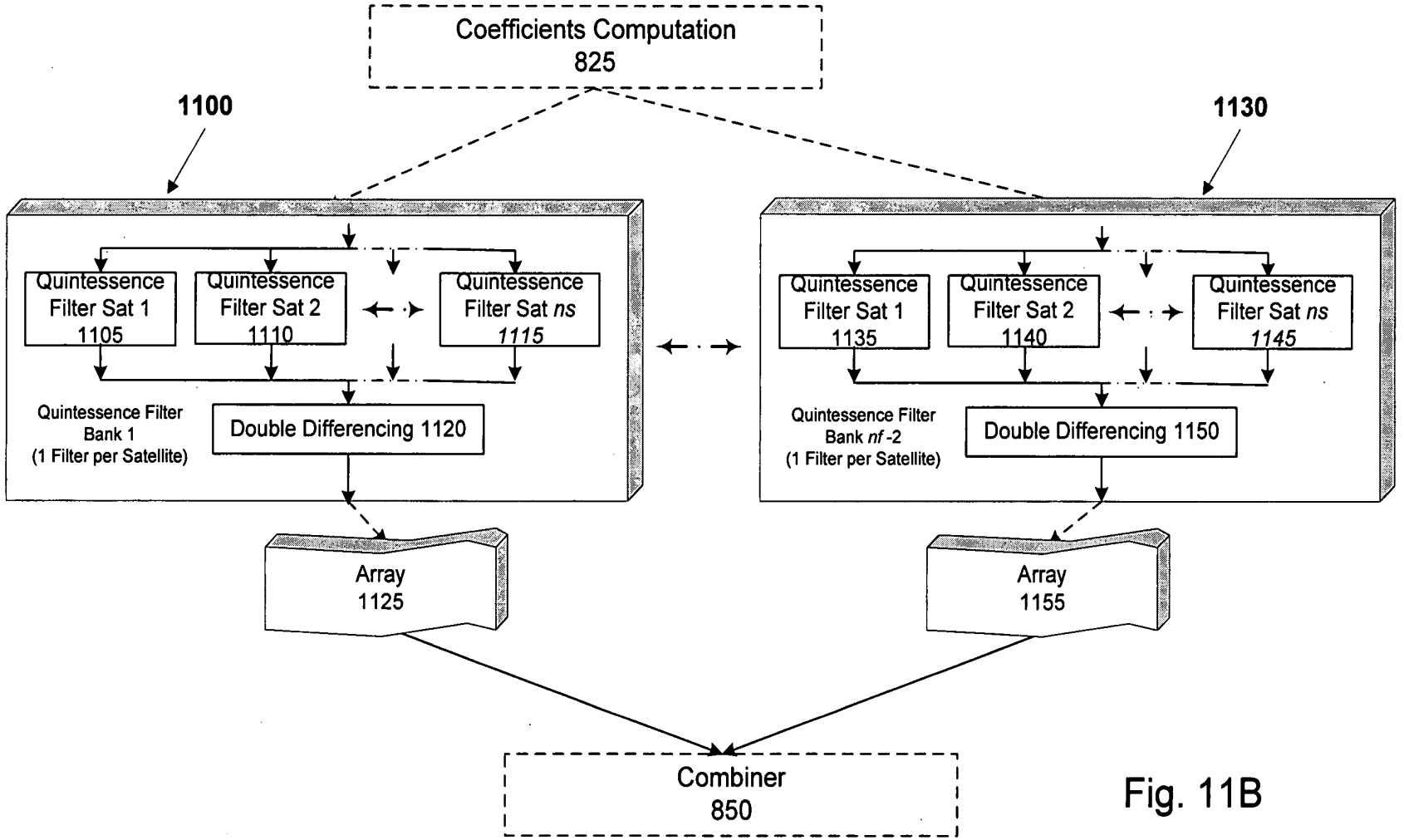

Coefficients Computation
825
1100
1130
Quintessence Filter Sat 1 1105
Quintessence Filter Sat 2 1110
Quintessence Filter Sat ns 1115
Quintessence Filter Bank 1 (1 Filter per Satellite)
Double Differencing 1120
Quintessence Filter Sat 1 1135
Quintessence Filter Sat 2 1140
Quintessence Filter Sat ns 1145
Quintessence Filter Bank nf -2 (1 Filter per Satellite)
Double Differencing 1150
Array 1125
Array 1155
Combiner 850

Fig. 11B

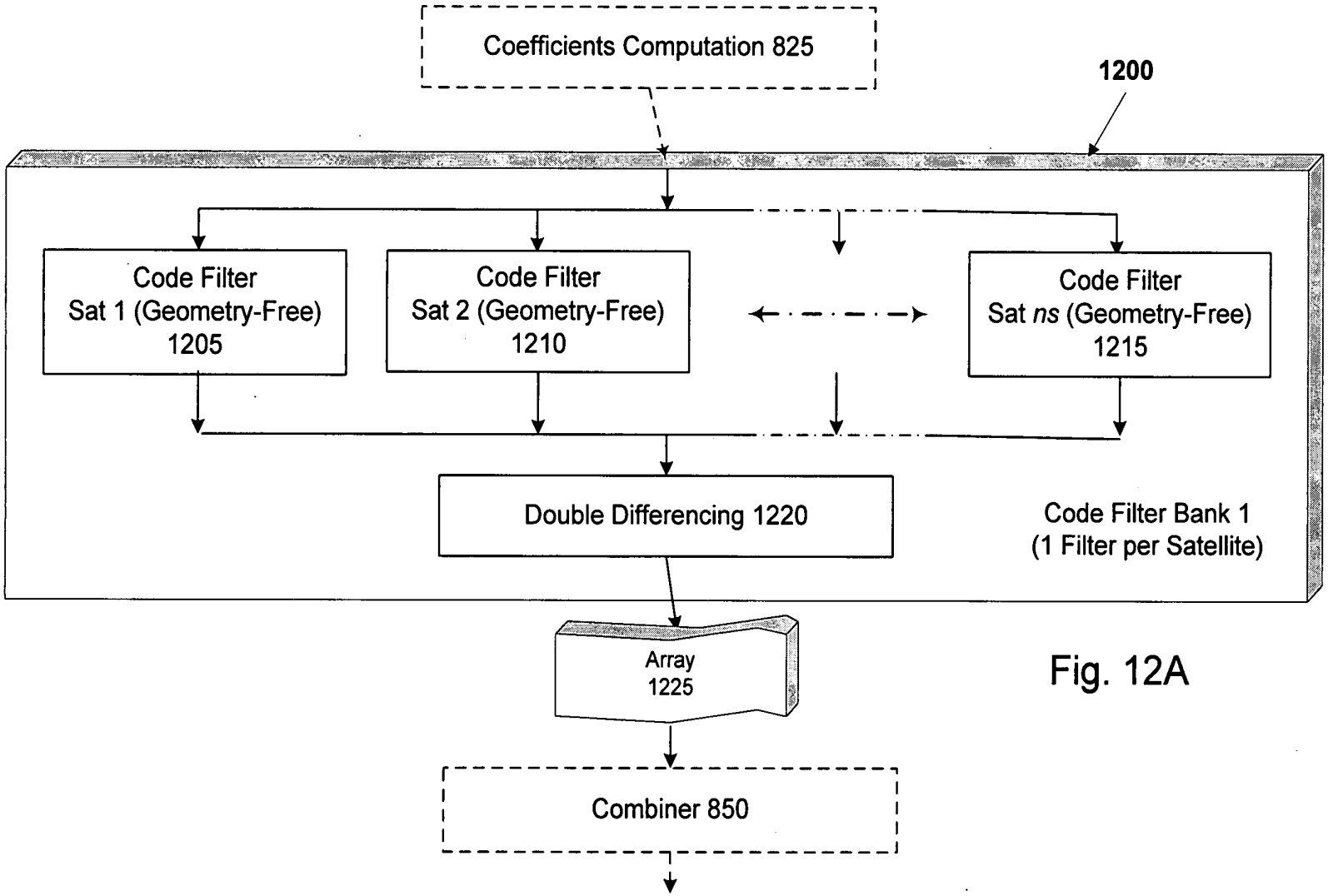

Coefficients Computation 825
1200
Code Filter
Sat 1 (Geometry-Free)
1205
Code Filter
Sat 2 (Geometry-Free)
1210
Code Filter
Sat ns (Geometry-Free)
1215
Double Differencing 1220
Code Filter Bank 1
(1 Filter per Satellite)
Array
1225
Combiner 850

Fig. 12A

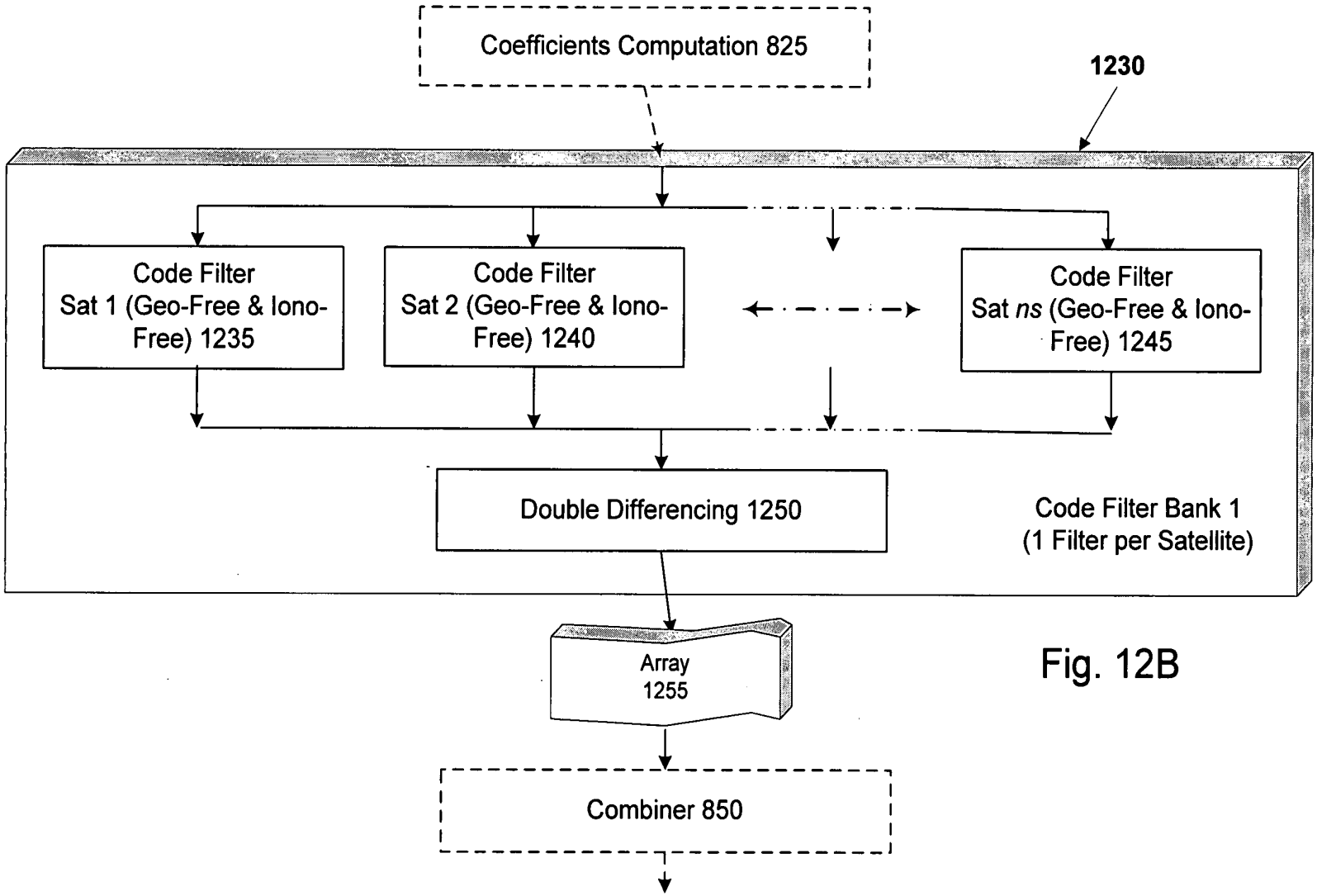

Coefficients Computation 825
1230
Code Filter
Sat 1 (Geo-Free & Iono-Free) 1235
Code Filter
Sat 2 (Geo-Free & Iono-Free) 1240
Code Filter
Sat ns (Geo-Free & Iono-Free) 1245
Double Differencing 1250
Code Filter Bank 1
(1 Filter per Satellite)
Array
1255
Combiner 850

Fig. 12B

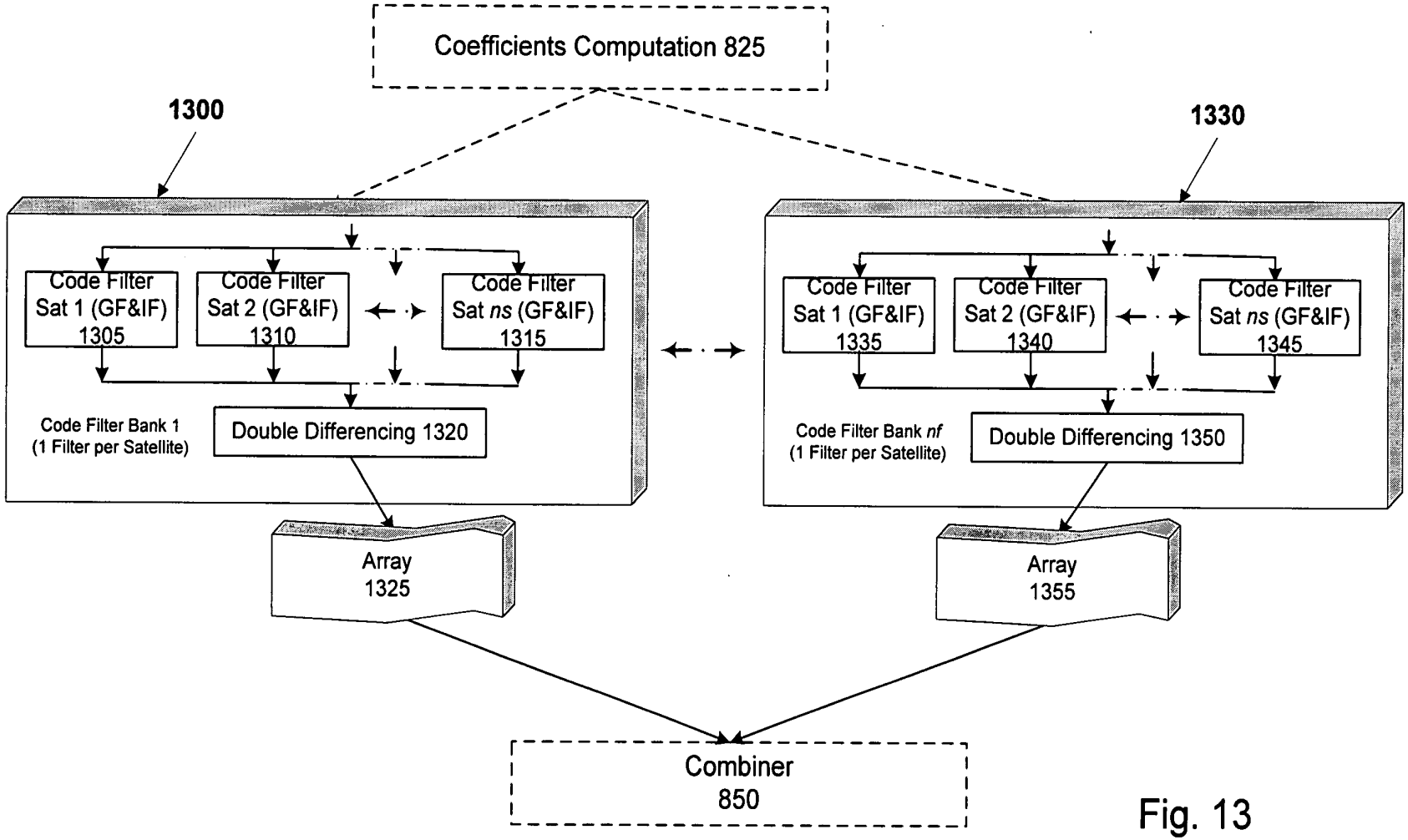

Coefficients Computation 825
1300
1330
Code Filter Sat 1 (GF&IF) 1305
Code Filter Sat 2 (GF&IF) 1310
Code Filter Sat ns (GF&IF) 1315
Code Filter Bank 1 (1 Filter per Satellite)
Double Differencing 1320
Array 1325
Code Filter Sat 1 (GF&IF) 1335
Code Filter Sat 2 (GF&IF) 1340
Code Filter Sat ns (GF&IF) 1345
Code Filter Bank nf (1 Filter per Satellite)
Double Differencing 1350
Array 1355
Combiner 850

Fig. 13

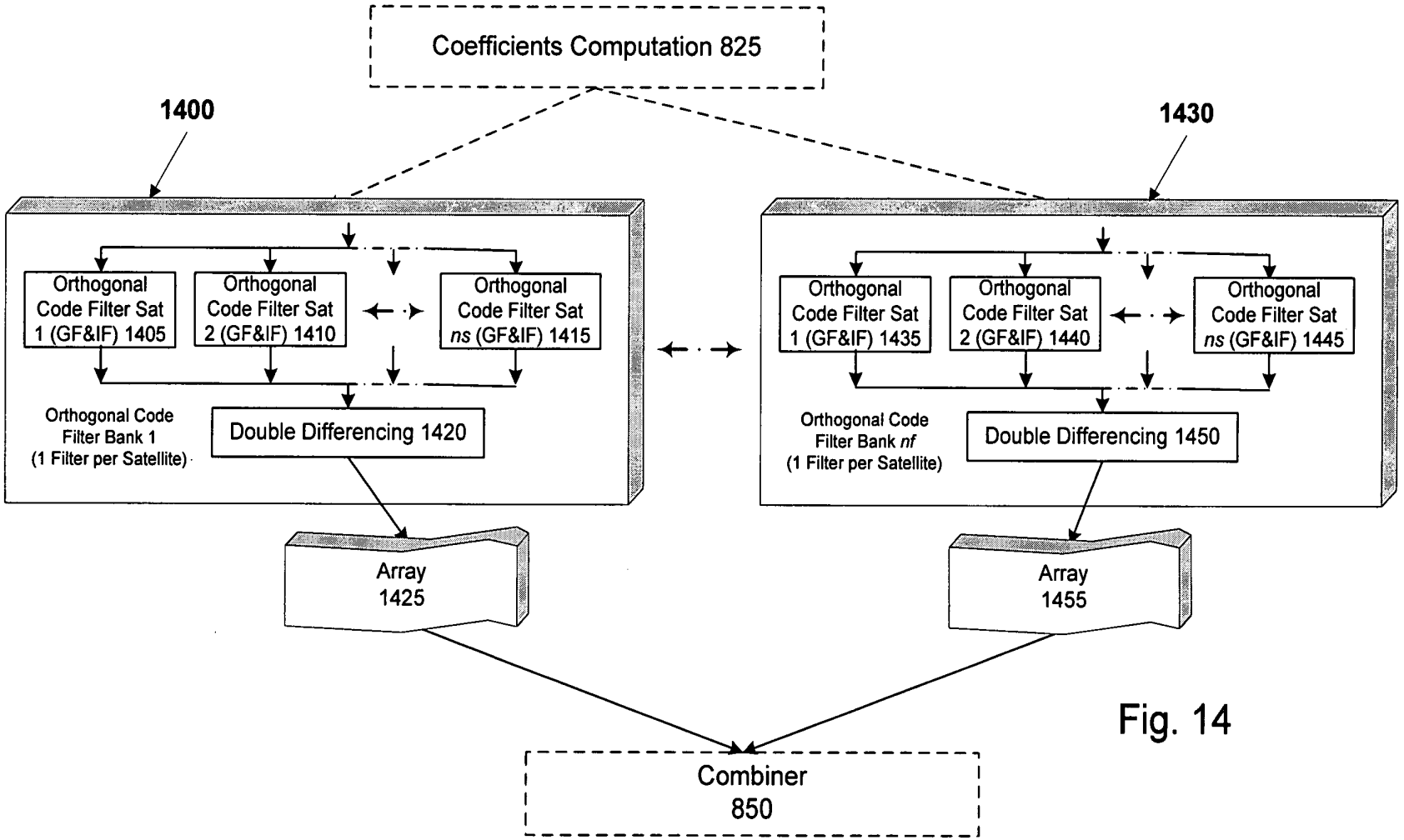

Coefficients Computation 825
1400
1430
Orthogonal Code Filter Sat 1 (GF&IF) 1405
Orthogonal Code Filter Sat 2 (GF&IF) 1410
Orthogonal Code Filter Sat ns (GF&IF) 1415
Orthogonal Code Filter Bank 1 (1 Filter per Satellite)
Double Differencing 1420
Array 1425
Orthogonal Code Filter Sat 1 (GF&IF) 1435
Orthogonal Code Filter Sat 2 (GF&IF) 1440
Orthogonal Code Filter Sat ns (GF&IF) 1445
Orthogonal Code Filter Bank nf (1 Filter per Satellite)
Double Differencing 1450
Array 1455
Combiner 850

Fig. 14

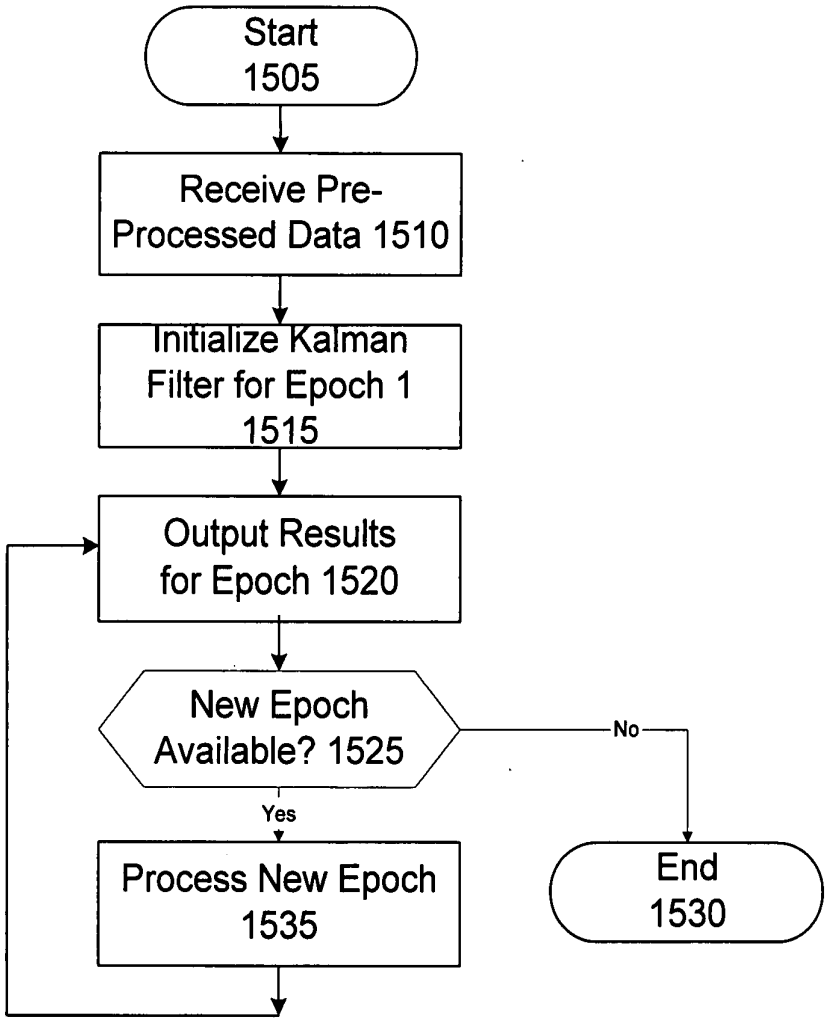

Start
1505
Receive Pre-Processed Data 1510
Initialize Kalman Filter for Epoch 1 1515
Output Results for Epoch 1520
New Epoch Available? 1525
No
Yes
Process New Epoch 1535
End
1530

Fig. 15

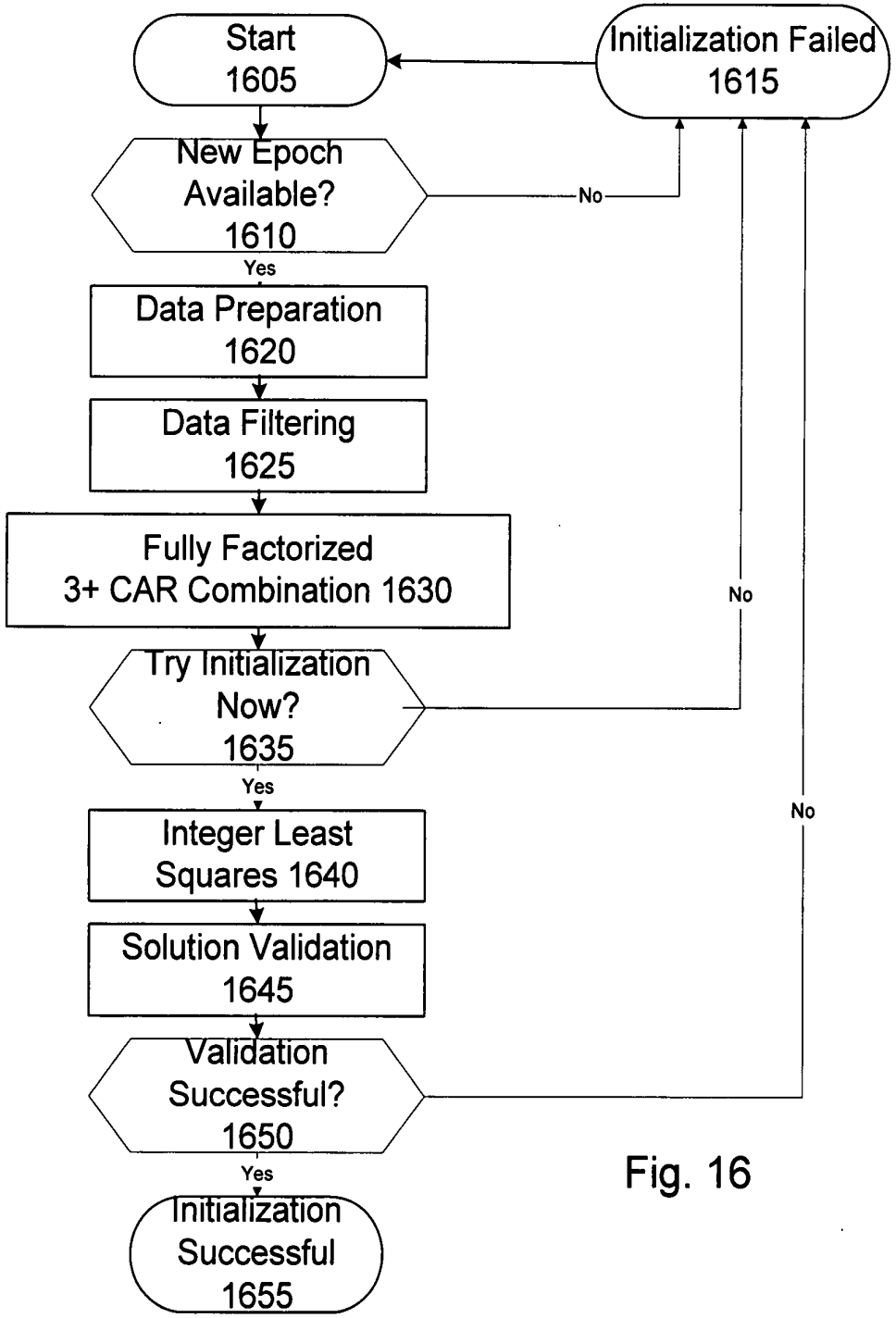

Start
1605
Initialization Failed
1615
New Epoch
Available?
1610
No
Yes
Data Preparation
1620
Data Filtering
1625
Fully Factorized
3+ CAR Combination 1630
No
Try Initialization
Now?
1635
Yes
No
Integer Least
Squares 1640
Solution Validation
1645
Validation
Successful?
1650
Yes
Initialization
Successful
1655

Fig. 16

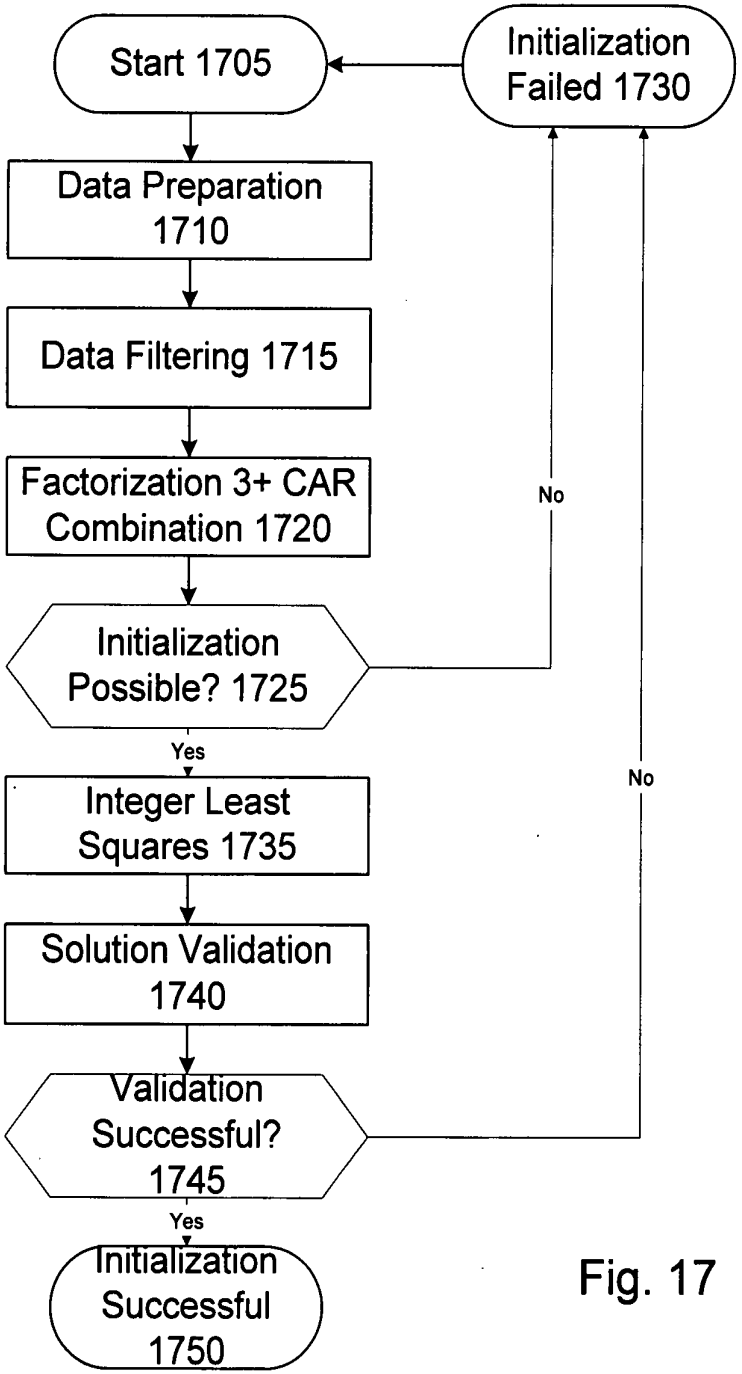

Start 1705
Initialization Failed 1730
Data Preparation 1710
Data Filtering 1715
Factorization 3+ CAR Combination 1720
No
Initialization Possible? 1725
Yes
No
Integer Least Squares 1735
Solution Validation 1740
Validation Successful? 1745
Yes
Initialization Successful 1750

Fig. 17

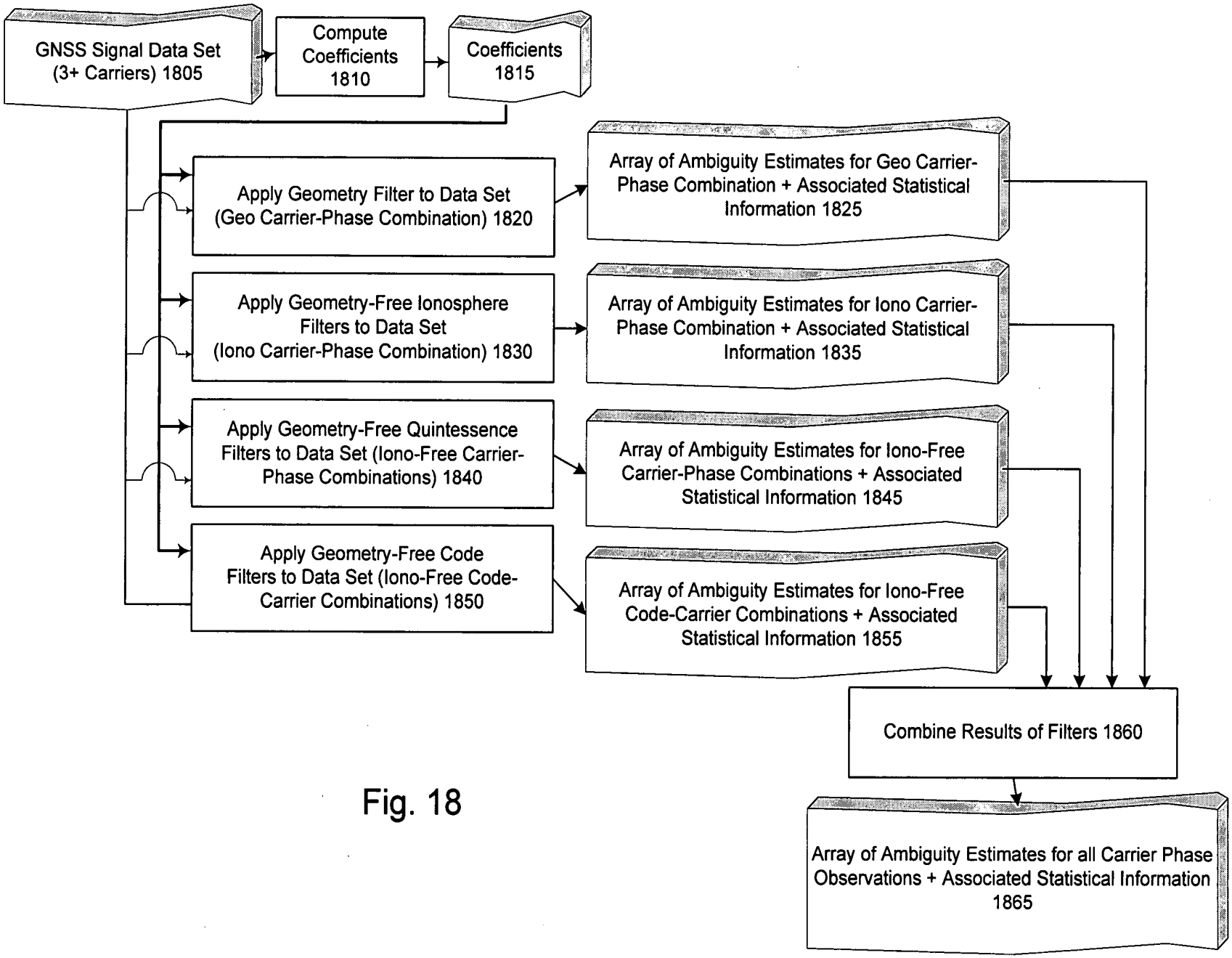

GNSS Signal Data Set (3+ Carriers) 1805
Compute Coefficients 1810
Coefficients 1815
Apply Geometry Filter to Data Set (Geo Carrier-Phase Combination) 1820
Array of Ambiguity Estimates for Geo Carrier-Phase Combination + Associated Statistical Information 1825
Apply Geometry-Free Ionosphere Filters to Data Set (Iono Carrier-Phase Combination) 1830
Array of Ambiguity Estimates for Iono Carrier-Phase Combination + Associated Statistical Information 1835
Apply Geometry-Free Quintessence Filters to Data Set (Iono-Free Carrier-Phase Combinations) 1840
Array of Ambiguity Estimates for Iono-Free Carrier-Phase Combinations + Associated Statistical Information 1845
Apply Geometry-Free Code Filters to Data Set (Iono-Free Code-Carrier Combinations) 1850
Array of Ambiguity Estimates for Iono-Free Code-Carrier Combinations + Associated Statistical Information 1855
Combine Results of Filters 1860
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information 1865

Fig. 18

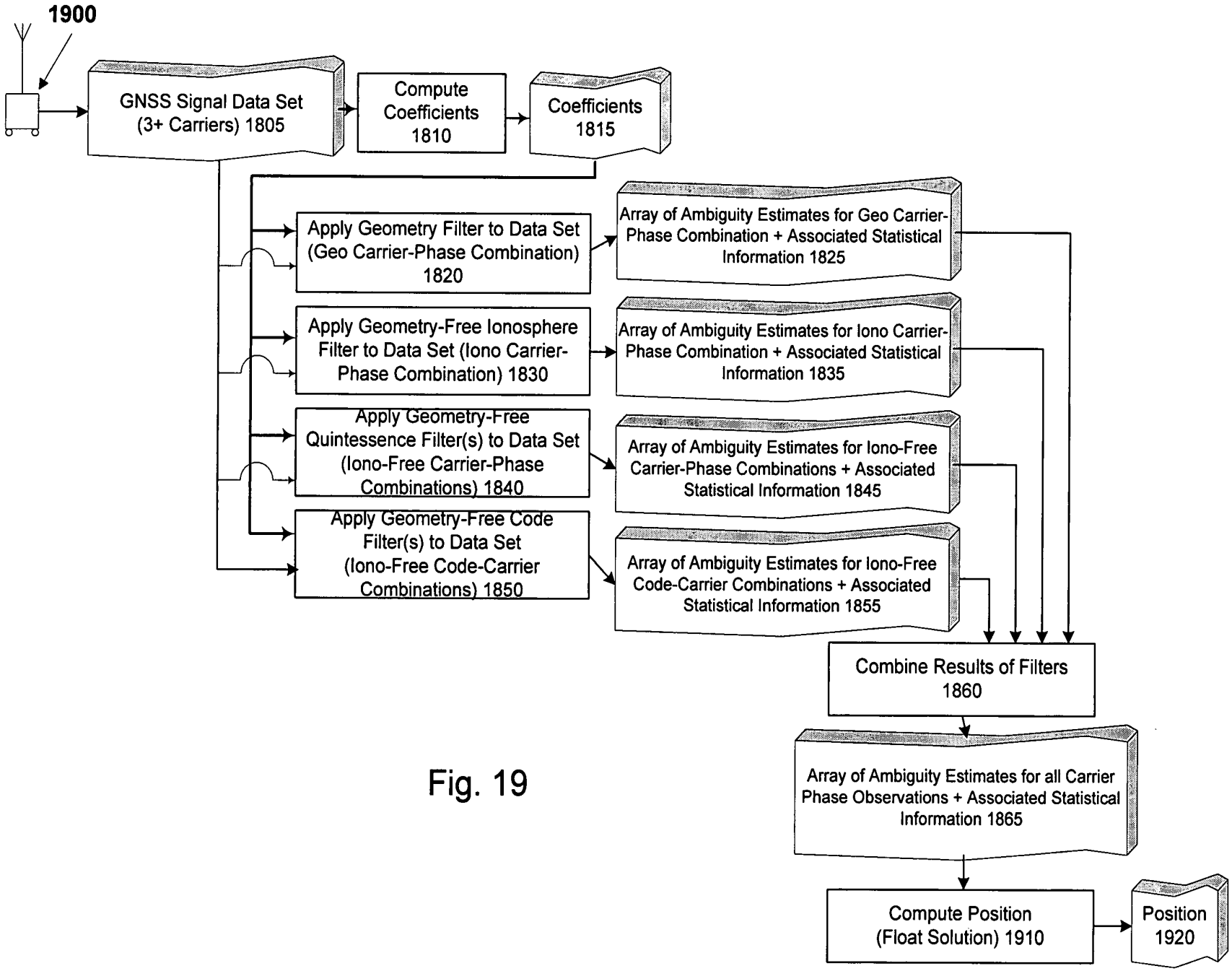

1900
GNSS Signal Data Set (3+ Carriers) 1805
Compute Coefficients 1810
Coefficients 1815
Apply Geometry Filter to Data Set (Geo Carrier-Phase Combination) 1820
Array of Ambiguity Estimates for Geo Carrier-Phase Combination + Associated Statistical Information 1825
Apply Geometry-Free Ionosphere Filter to Data Set (Iono Carrier-Phase Combination) 1830
Array of Ambiguity Estimates for Iono Carrier-Phase Combination + Associated Statistical Information 1835
Apply Geometry-Free Quintessence Filter(s) to Data Set (Iono-Free Carrier-Phase Combinations) 1840
Array of Ambiguity Estimates for Iono-Free Carrier-Phase Combinations + Associated Statistical Information 1845
Apply Geometry-Free Code Filter(s) to Data Set (Iono-Free Code-Carrier Combinations) 1850
Array of Ambiguity Estimates for Iono-Free Code-Carrier Combinations + Associated Statistical Information 1855
Combine Results of Filters 1860
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information 1865
Compute Position (Float Solution) 1910
Position 1920

Fig. 19

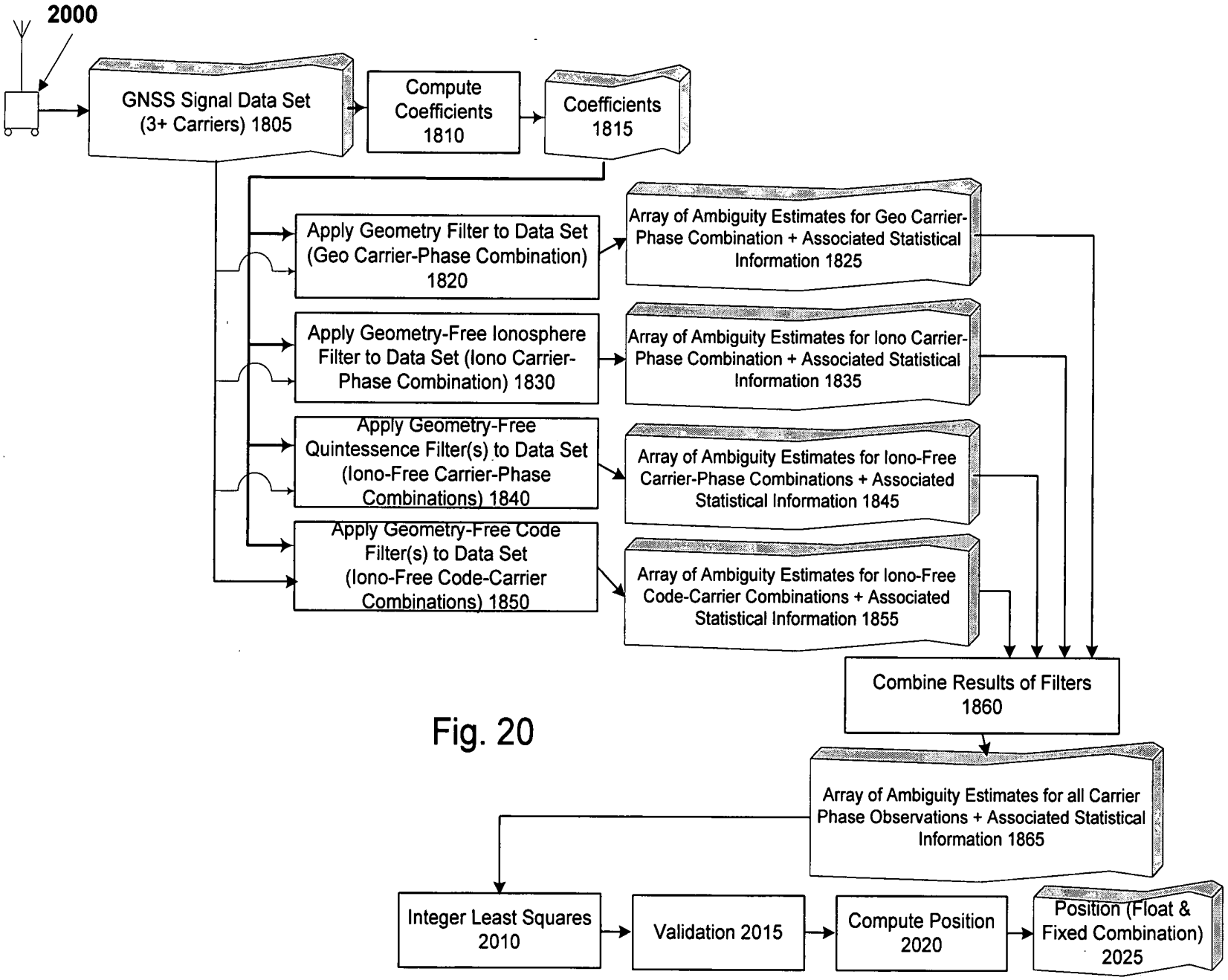

2000
GNSS Signal Data Set (3+ Carriers) 1805
Compute Coefficients 1810
Coefficients 1815
Apply Geometry Filter to Data Set (Geo Carrier-Phase Combination) 1820
Array of Ambiguity Estimates for Geo Carrier-Phase Combination + Associated Statistical Information 1825
Apply Geometry-Free Ionosphere Filter to Data Set (Iono Carrier-Phase Combination) 1830
Array of Ambiguity Estimates for Iono Carrier-Phase Combination + Associated Statistical Information 1835
Apply Geometry-Free Quintessence Filter(s) to Data Set (Iono-Free Carrier-Phase Combinations) 1840
Array of Ambiguity Estimates for Iono-Free Carrier-Phase Combinations + Associated Statistical Information 1845
Apply Geometry-Free Code Filter(s) to Data Set (Iono-Free Code-Carrier Combinations) 1850
Array of Ambiguity Estimates for Iono-Free Code-Carrier Combinations + Associated Statistical Information 1855
Combine Results of Filters 1860
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information 1865
Integer Least Squares 2010
Validation 2015
Compute Position 2020
Position (Float & Fixed Combination) 2025

Fig. 20

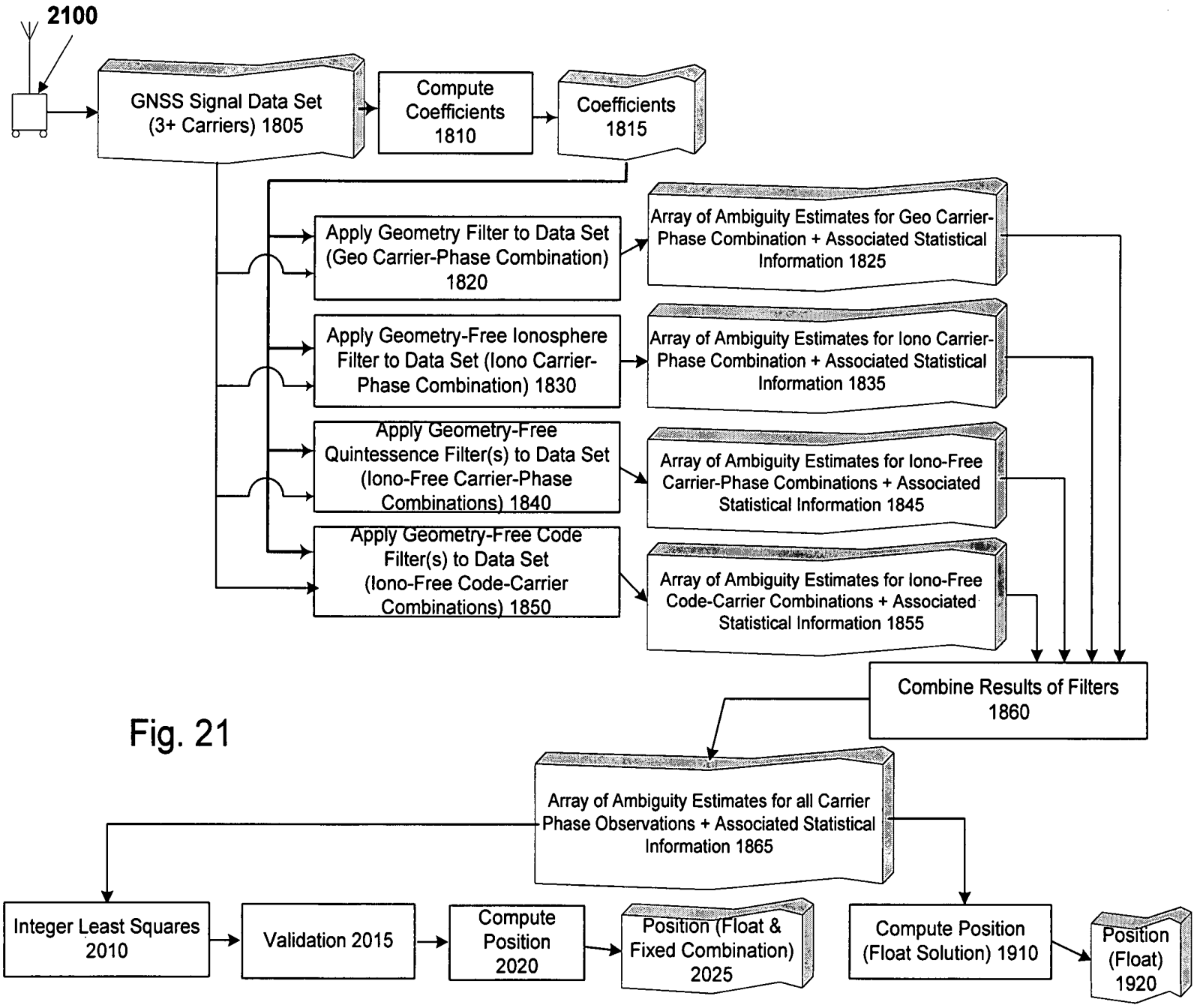

2100
GNSS Signal Data Set (3+ Carriers) 1805
Compute Coefficients 1810
Coefficients 1815
Apply Geometry Filter to Data Set (Geo Carrier-Phase Combination) 1820
Array of Ambiguity Estimates for Geo Carrier-Phase Combination + Associated Statistical Information 1825
Apply Geometry-Free Ionosphere Filter to Data Set (Iono Carrier-Phase Combination) 1830
Array of Ambiguity Estimates for Iono Carrier-Phase Combination + Associated Statistical Information 1835
Apply Geometry-Free Quintessence Filter(s) to Data Set (Iono-Free Carrier-Phase Combinations) 1840
Array of Ambiguity Estimates for Iono-Free Carrier-Phase Combinations + Associated Statistical Information 1845
Apply Geometry-Free Code Filter(s) to Data Set (Iono-Free Code-Carrier Combinations) 1850
Array of Ambiguity Estimates for Iono-Free Code-Carrier Combinations + Associated Statistical Information 1855
Combine Results of Filters 1860
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information 1865
Integer Least Squares 2010
Validation 2015
Compute Position 2020
Position (Float & Fixed Combination) 2025
Compute Position (Float Solution) 1910
Position (Float) 1920

Fig. 21

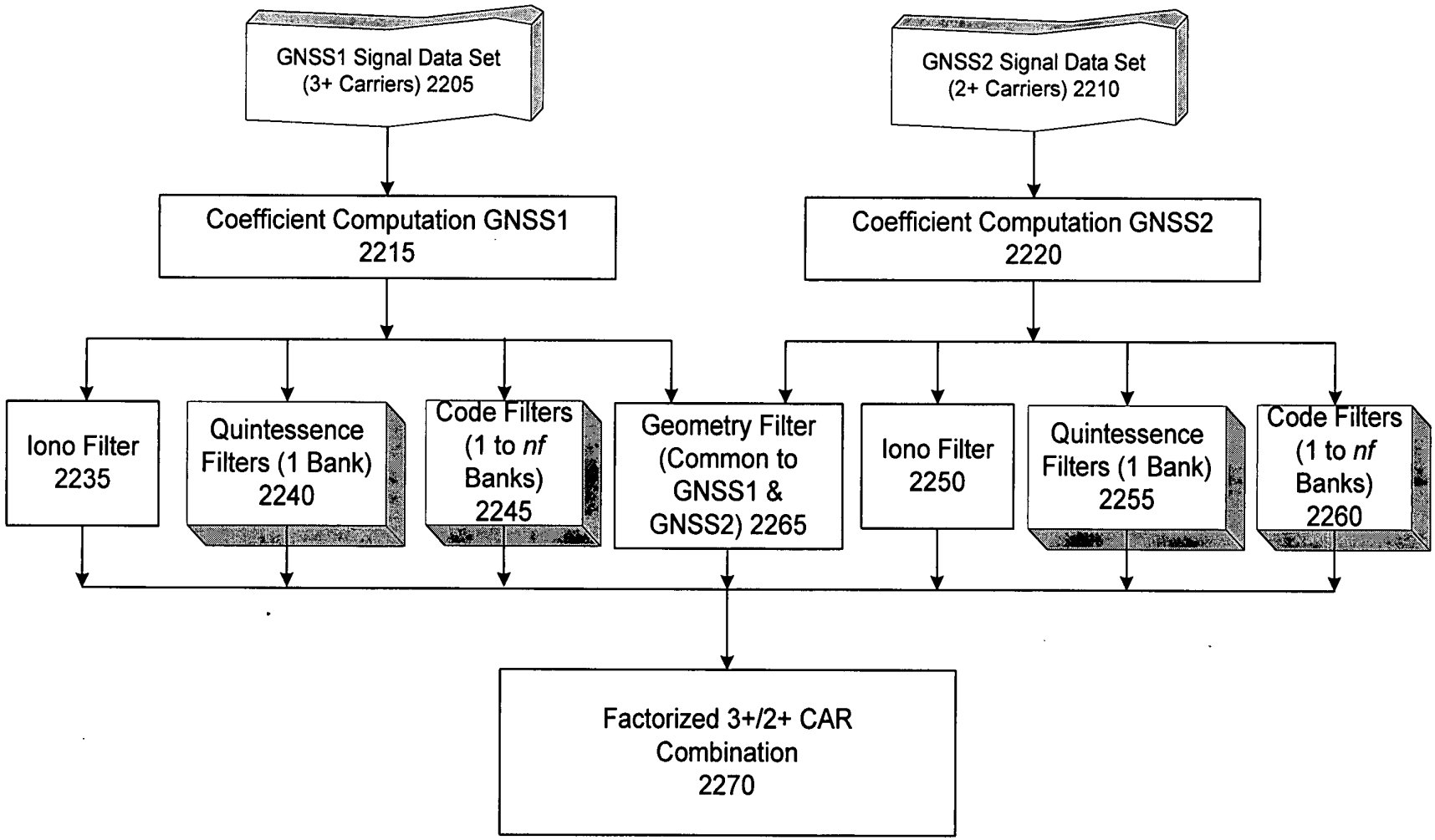

GNSS1 Signal Data Set (3+ Carriers) 2205
GNSS2 Signal Data Set (2+ Carriers) 2210
Coefficient Computation GNSS1 2215
Coefficient Computation GNSS2 2220
Iono Filter 2235
Quintessence Filters (1 Bank) 2240
Code Filters (1 to nf Banks) 2245
Geometry Filter (Common to GNSS1 & GNSS2) 2265
Iono Filter 2250
Quintessence Filters (1 Bank) 2255
Code Filters (1 to nf Banks) 2260
Factorized 3+/2+ CAR Combination 2270

Fig. 22

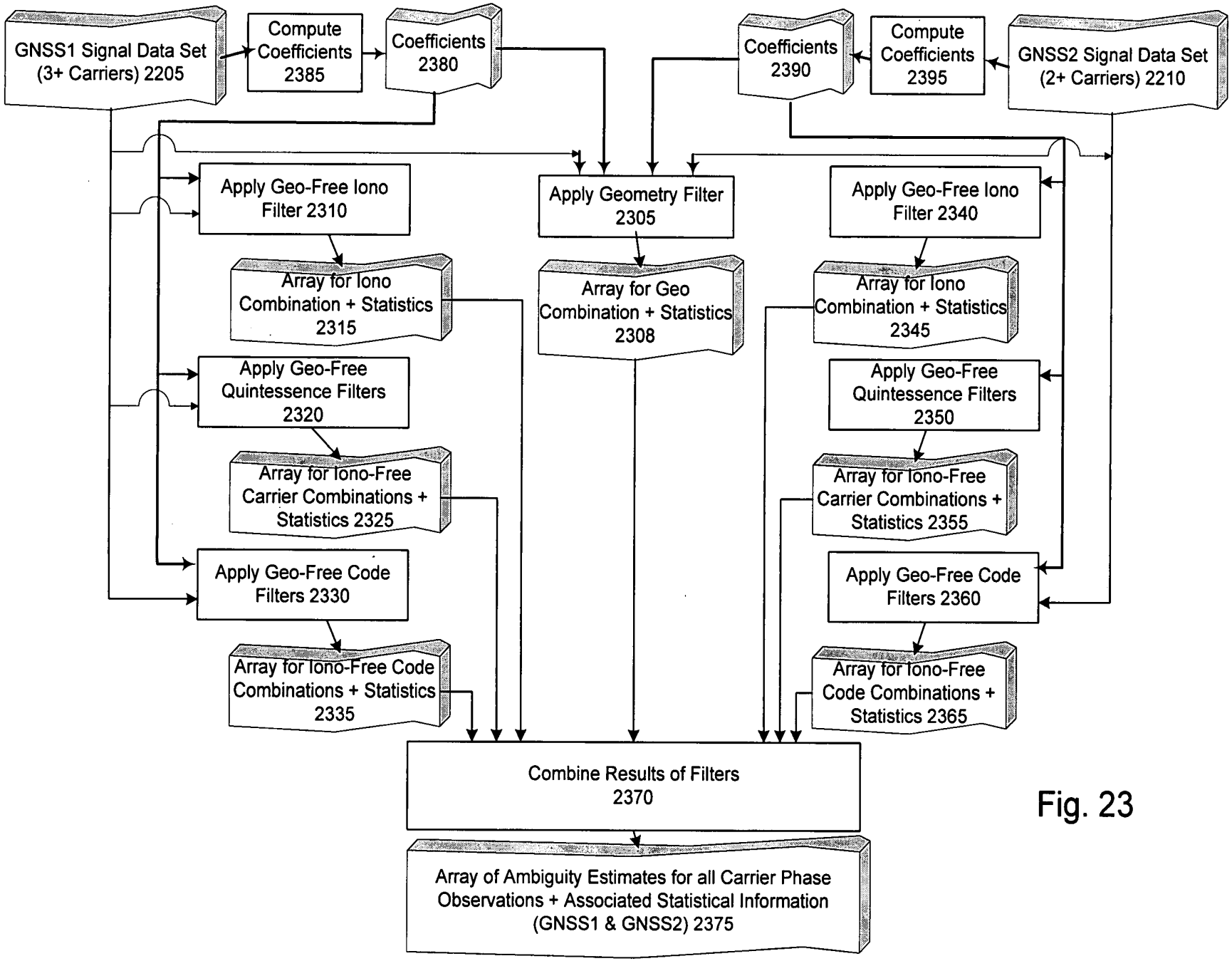

GNSS1 Signal Data Set (3+ Carriers) 2205
Compute Coefficients 2385
Coefficients 2380
Coefficients 2390
Compute Coefficients 2395
GNSS2 Signal Data Set (2+ Carriers) 2210
Apply Geo-Free Iono Filter 2310
Apply Geometry Filter 2305
Apply Geo-Free Iono Filter 2340
Array for Iono Combination + Statistics 2315
Array for Geo Combination + Statistics 2308
Array for Iono Combination + Statistics 2345
Apply Geo-Free Quintessence Filters 2320
Apply Geo-Free Quintessence Filters 2350
Array for Iono-Free Carrier Combinations + Statistics 2325
Array for Iono-Free Carrier Combinations + Statistics 2355
Apply Geo-Free Code Filters 2330
Apply Geo-Free Code Filters 2360
Array for Iono-Free Code Combinations + Statistics 2335
Array for Iono-Free Code Combinations + Statistics 2365
Combine Results of Filters 2370
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information (GNSS1 & GNSS2) 2375

Fig. 23

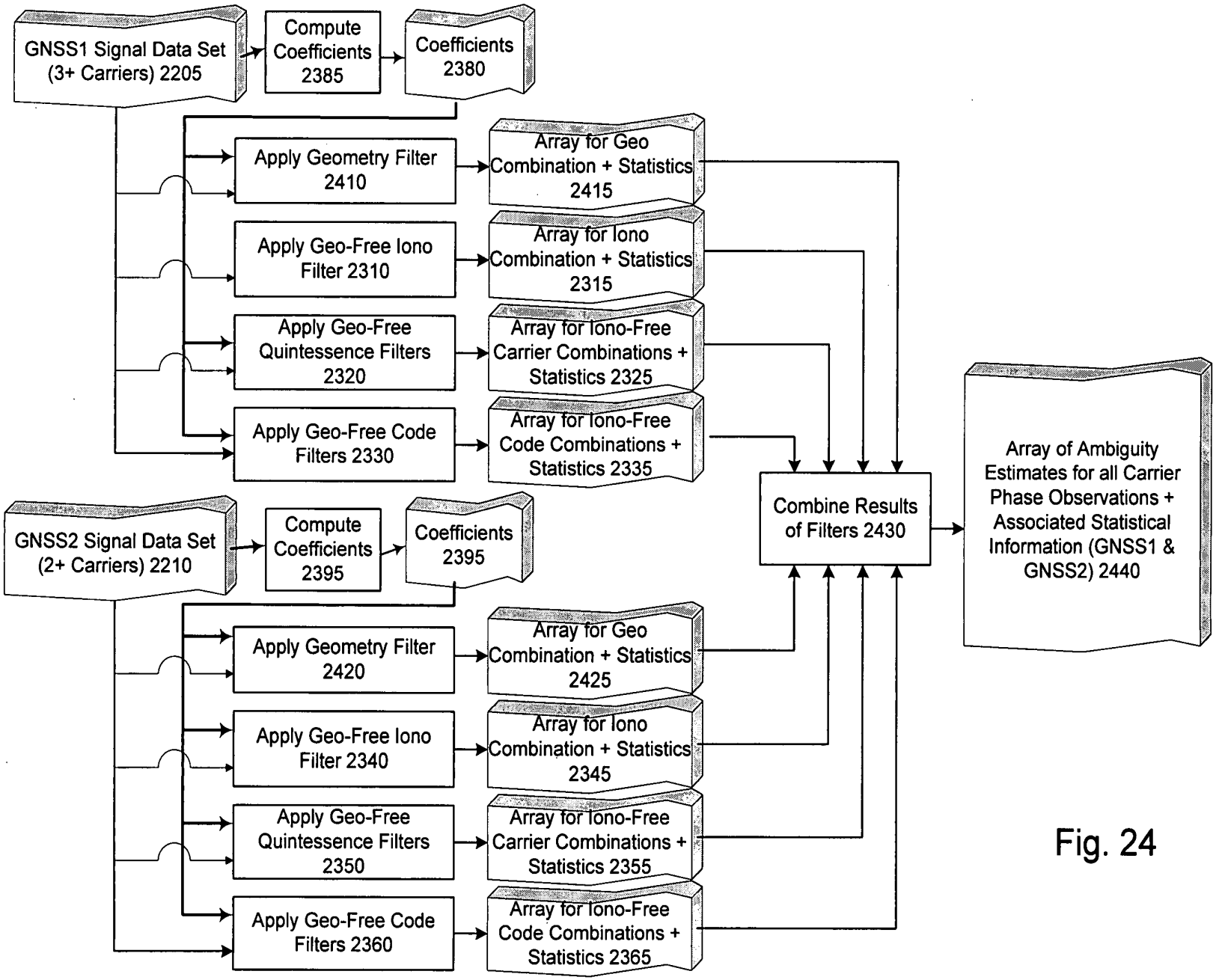

GNSS1 Signal Data Set (3+ Carriers) 2205
Compute Coefficients 2385
Coefficients 2380
Apply Geometry Filter 2410
Array for Geo Combination + Statistics 2415
Apply Geo-Free Iono Filter 2310
Array for Iono Combination + Statistics 2315
Apply Geo-Free Quintessence Filters 2320
Array for Iono-Free Carrier Combinations + Statistics 2325
Apply Geo-Free Code Filters 2330
Array for Iono-Free Code Combinations + Statistics 2335
GNSS2 Signal Data Set (2+ Carriers) 2210
Compute Coefficients 2395
Coefficients 2395
Apply Geometry Filter 2420
Array for Geo Combination + Statistics 2425
Apply Geo-Free Iono Filter 2340
Array for Iono Combination + Statistics 2345
Apply Geo-Free Quintessence Filters 2350
Array for Iono-Free Carrier Combinations + Statistics 2355
Apply Geo-Free Code Filters 2360
Array for Iono-Free Code Combinations + Statistics 2365
Combine Results of Filters 2430
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information (GNSS1 & GNSS2) 2440

Fig. 24

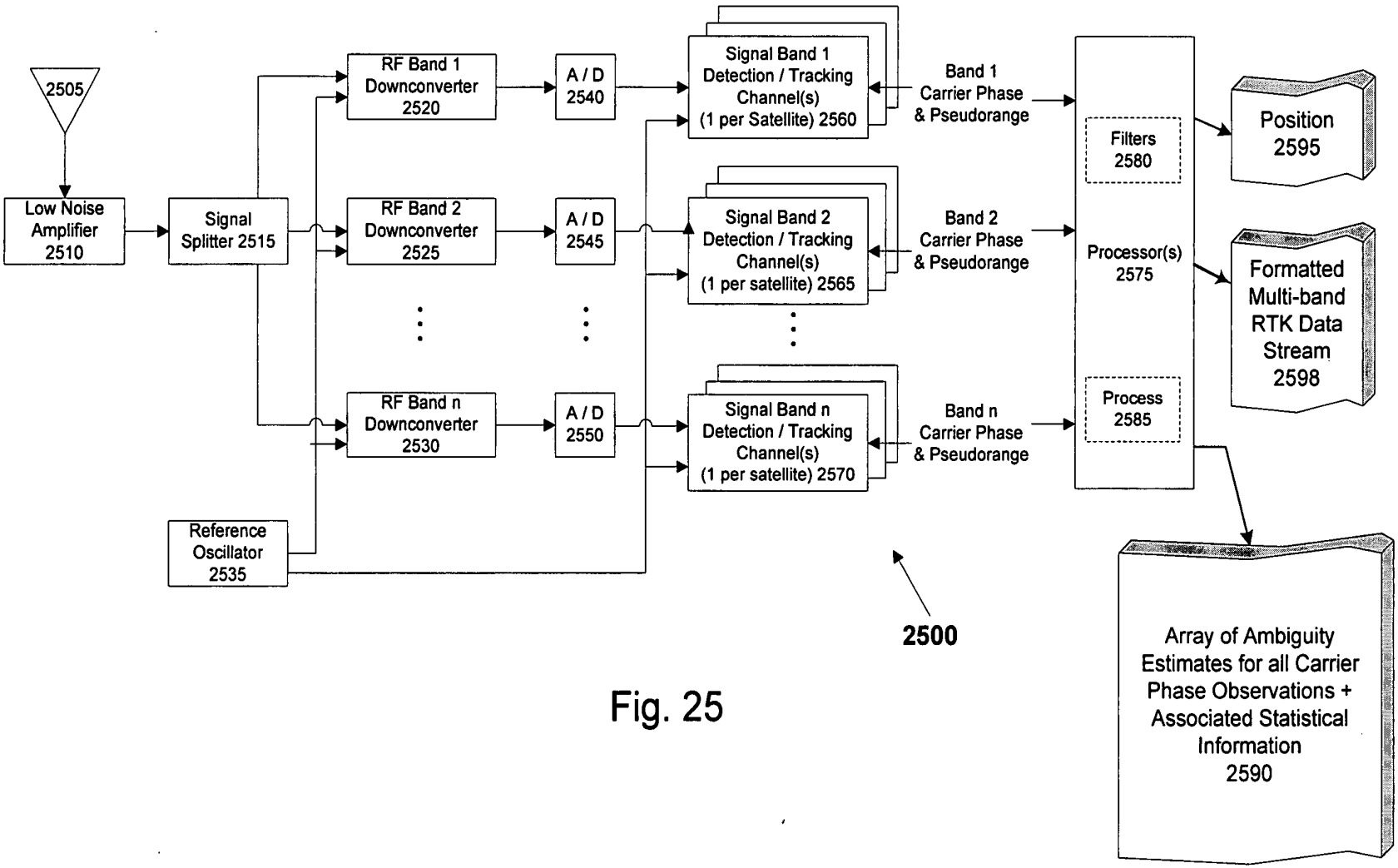

2505
Low Noise Amplifier 2510
Signal Splitter 2515
RF Band 1 Downconverter 2520
RF Band 2 Downconverter 2525
RF Band n Downconverter 2530
Reference Oscillator 2535
A / D 2540
A / D 2545
A / D 2550
Signal Band 1 Detection / Tracking Channel(s) (1 per Satellite) 2560
Signal Band 2 Detection / Tracking Channel(s) (1 per satellite) 2565
Signal Band n Detection / Tracking Channel(s) (1 per satellite) 2570
Band 1 Carrier Phase & Pseudorange
Band 2 Carrier Phase & Pseudorange
Band n Carrier Phase & Pseudorange
Filters 2580
Processor(s) 2575
Process 2585
Position 2595
Formatted Multi-band RTK Data Stream 2598
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information 2590
2500

Fig. 25

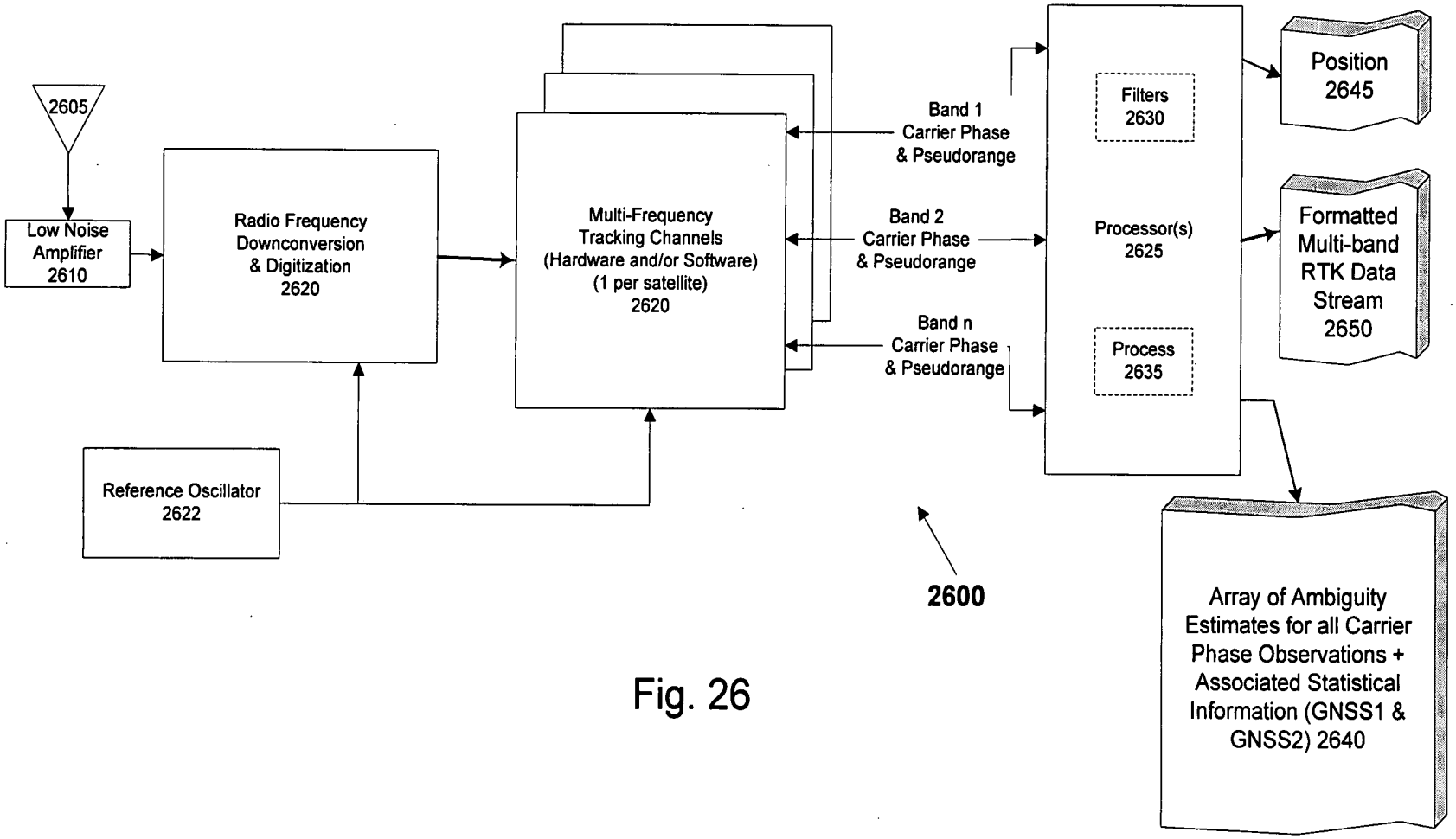

2605
Low Noise Amplifier 2610
Radio Frequency Downconversion & Digitization 2620
Multi-Frequency Tracking Channels (Hardware and/or Software) (1 per satellite) 2620
Reference Oscillator 2622
Band 1 Carrier Phase & Pseudorange
Band 2 Carrier Phase & Pseudorange
Band n Carrier Phase & Pseudorange
Filters 2630
Processor(s) 2625
Process 2635
Position 2645
Formatted Multi-band RTK Data Stream 2650
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information (GNSS1 & GNSS2) 2640
2600

Fig. 26

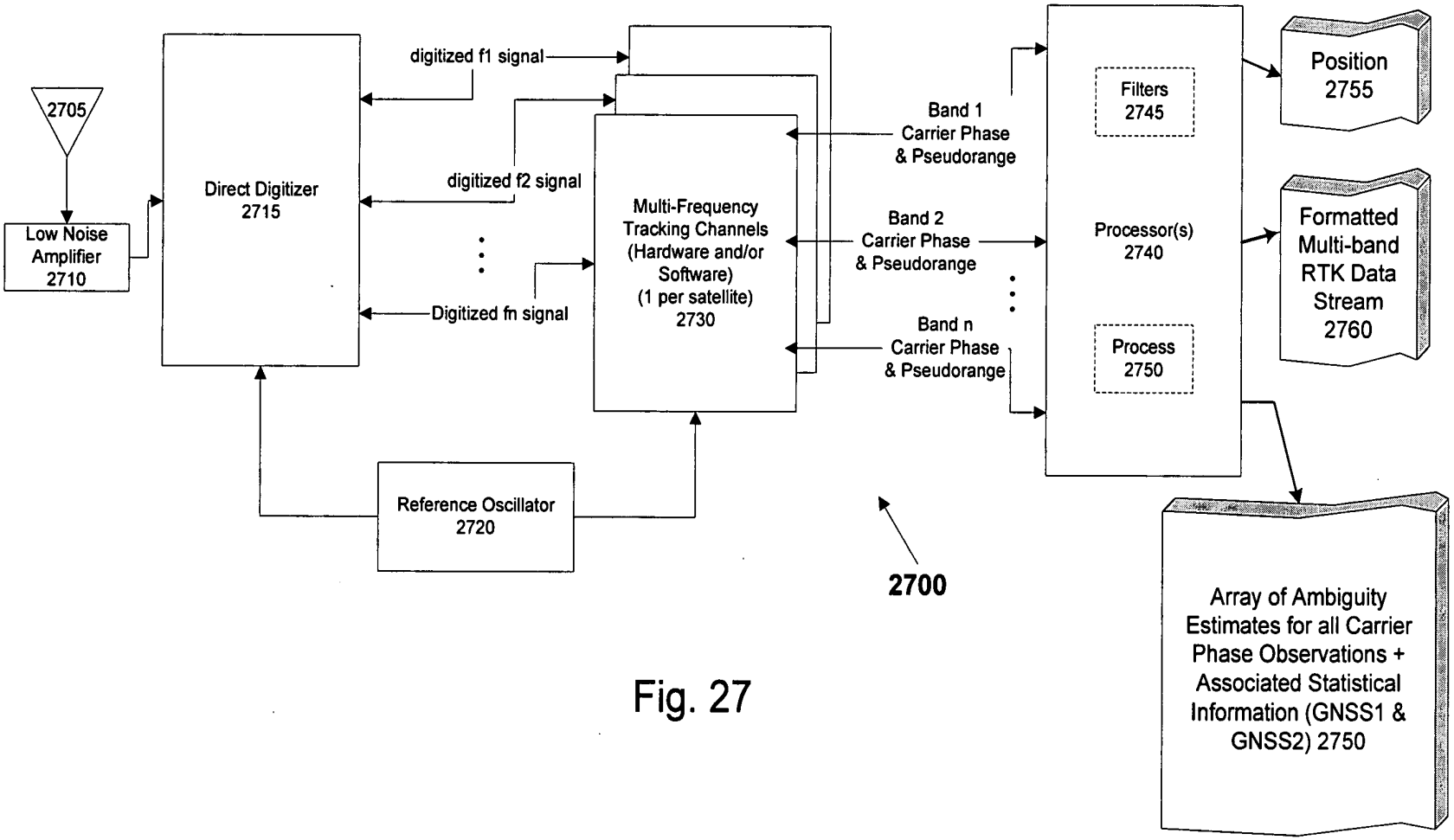

2705
Low Noise Amplifier 2710
Direct Digitizer 2715
digitized f1 signal
digitized f2 signal
Digitized fn signal
Multi-Frequency Tracking Channels (Hardware and/or Software) (1 per satellite) 2730
Band 1 Carrier Phase & Pseudorange
Band 2 Carrier Phase & Pseudorange
Band n Carrier Phase & Pseudorange
Filters 2745
Processor(s) 2740
Process 2750
Position 2755
Formatted Multi-band RTK Data Stream 2760
Reference Oscillator 2720
2700
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information (GNSS1 & GNSS2) 2750

Fig. 27

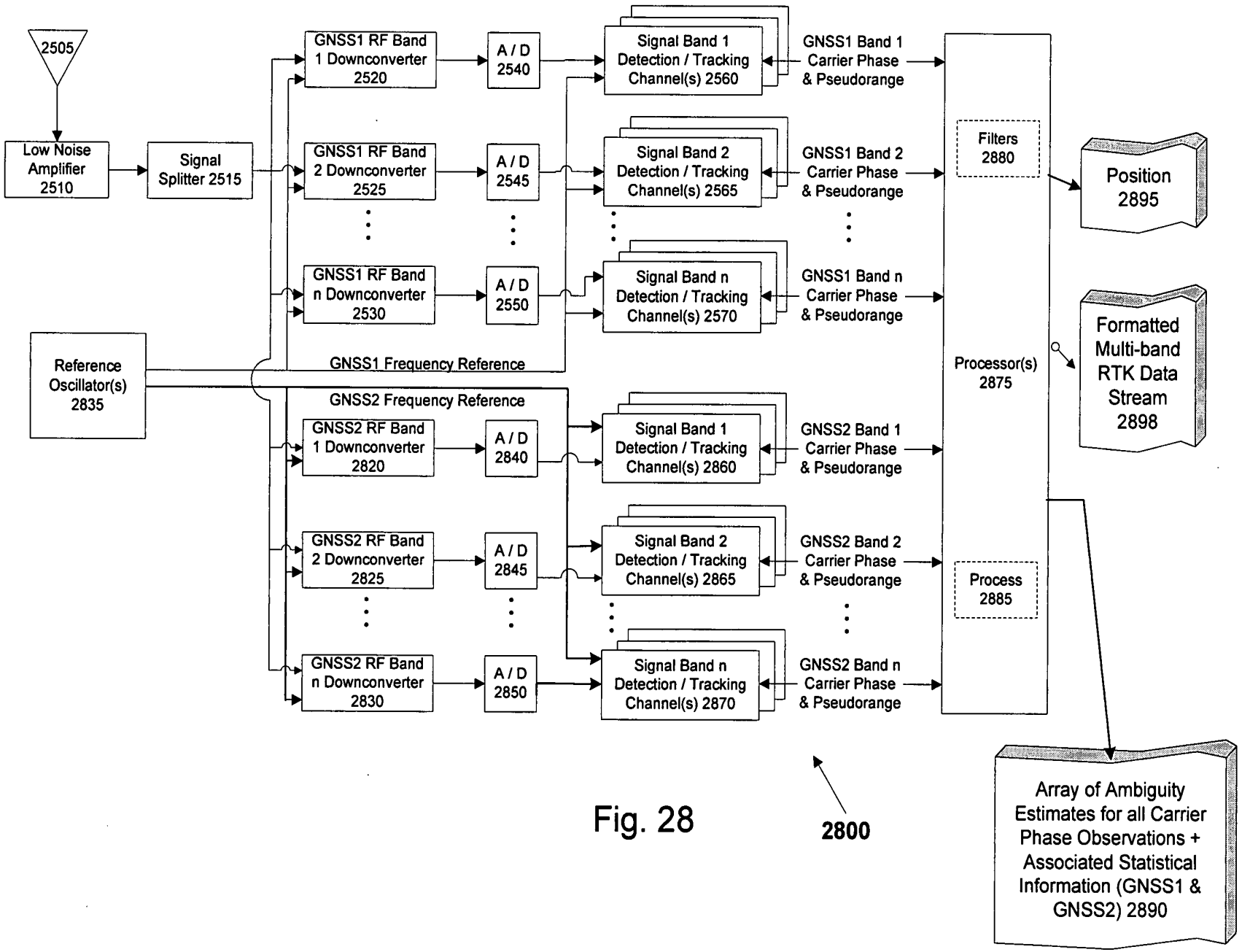

2505
Low Noise Amplifier 2510
Signal Splitter 2515
GNSS1 RF Band 1 Downconverter 2520
GNSS1 RF Band 2 Downconverter 2525
GNSS1 RF Band n Downconverter 2530
A / D 2540
A / D 2545
A / D 2550
Signal Band 1 Detection / Tracking Channel(s) 2560
Signal Band 2 Detection / Tracking Channel(s) 2565
Signal Band n Detection / Tracking Channel(s) 2570
GNSS1 Band 1 Carrier Phase & Pseudorange
GNSS1 Band 2 Carrier Phase & Pseudorange
GNSS1 Band n Carrier Phase & Pseudorange
Reference Oscillator(s) 2835
GNSS1 Frequency Reference
GNSS2 Frequency Reference
GNSS2 RF Band 1 Downconverter 2820
GNSS2 RF Band 2 Downconverter 2825
GNSS2 RF Band n Downconverter 2830
A / D 2840
A / D 2845
A / D 2850
Signal Band 1 Detection / Tracking Channel(s) 2860
Signal Band 2 Detection / Tracking Channel(s) 2865
Signal Band n Detection / Tracking Channel(s) 2870
GNSS2 Band 1 Carrier Phase & Pseudorange
GNSS2 Band 2 Carrier Phase & Pseudorange
GNSS2 Band n Carrier Phase & Pseudorange
Filters 2880
Processor(s) 2875
Process 2885
Position 2895
Formatted Multi-band RTK Data Stream 2898
Array of Ambiguity Estimates for all Carrier Phase Observations + Associated Statistical Information (GNSS1 & GNSS2) 2890
2800

Fig. 28

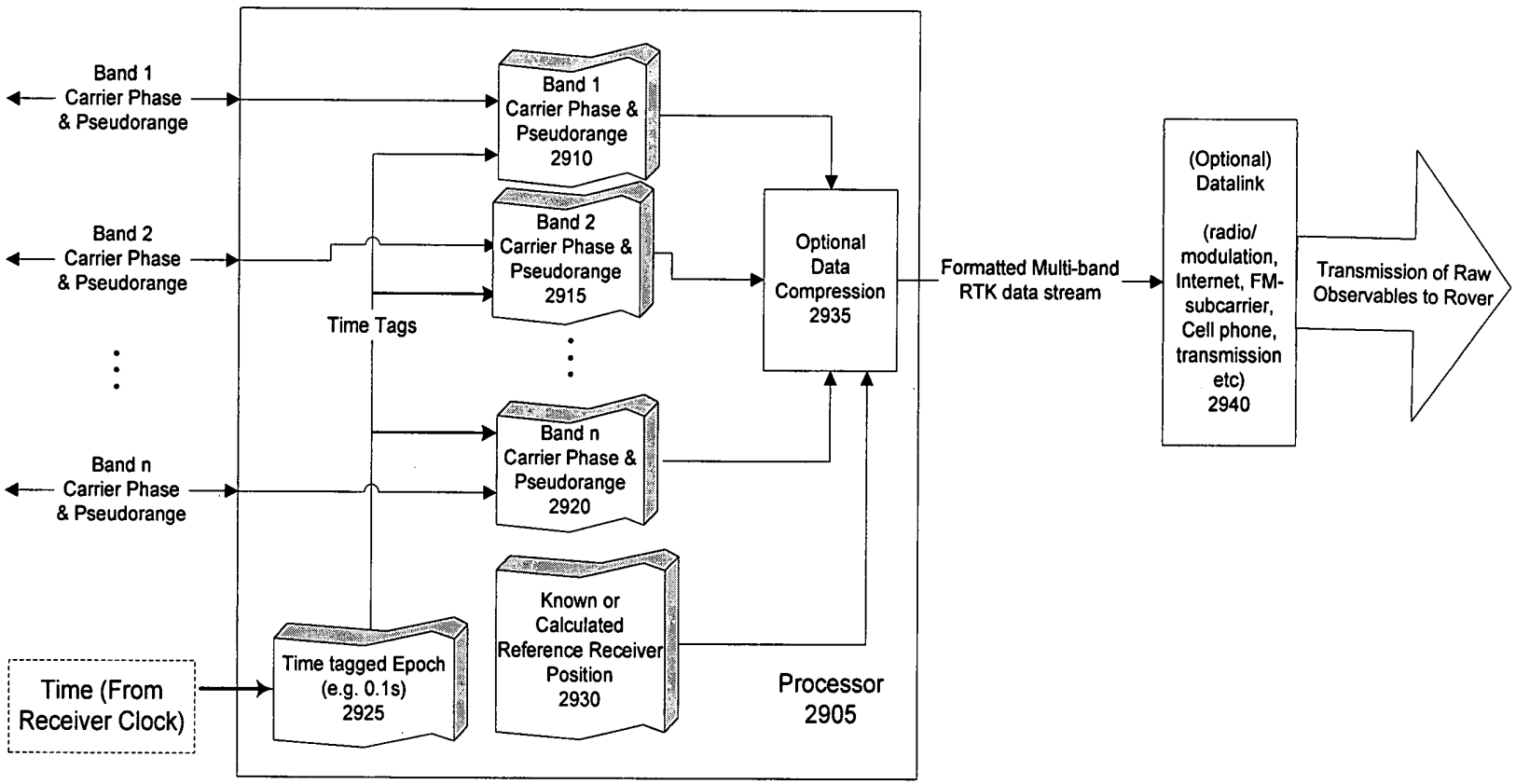

Band 1
Carrier Phase
& Pseudorange
Band 2
Carrier Phase
& Pseudorange
Band n
Carrier Phase
& Pseudorange
Time (From
Receiver Clock)
Time tagged Epoch
(e.g. 0.1s)
2925
Time Tags
Band 1
Carrier Phase &
Pseudorange
2910
Band 2
Carrier Phase &
Pseudorange
2915
Band n
Carrier Phase &
Pseudorange
2920
Known or
Calculated
Reference Receiver
Position
2930
Processor
2905
Optional
Data
Compression
2935
Formatted Multi-band
RTK data stream
(Optional)
Datalink
(radio/
modulation,
Internet, FM-
subcarrier,
Cell phone,
transmission
etc)
2940
Transmission of Raw
Observables to Rover

Fig. 29

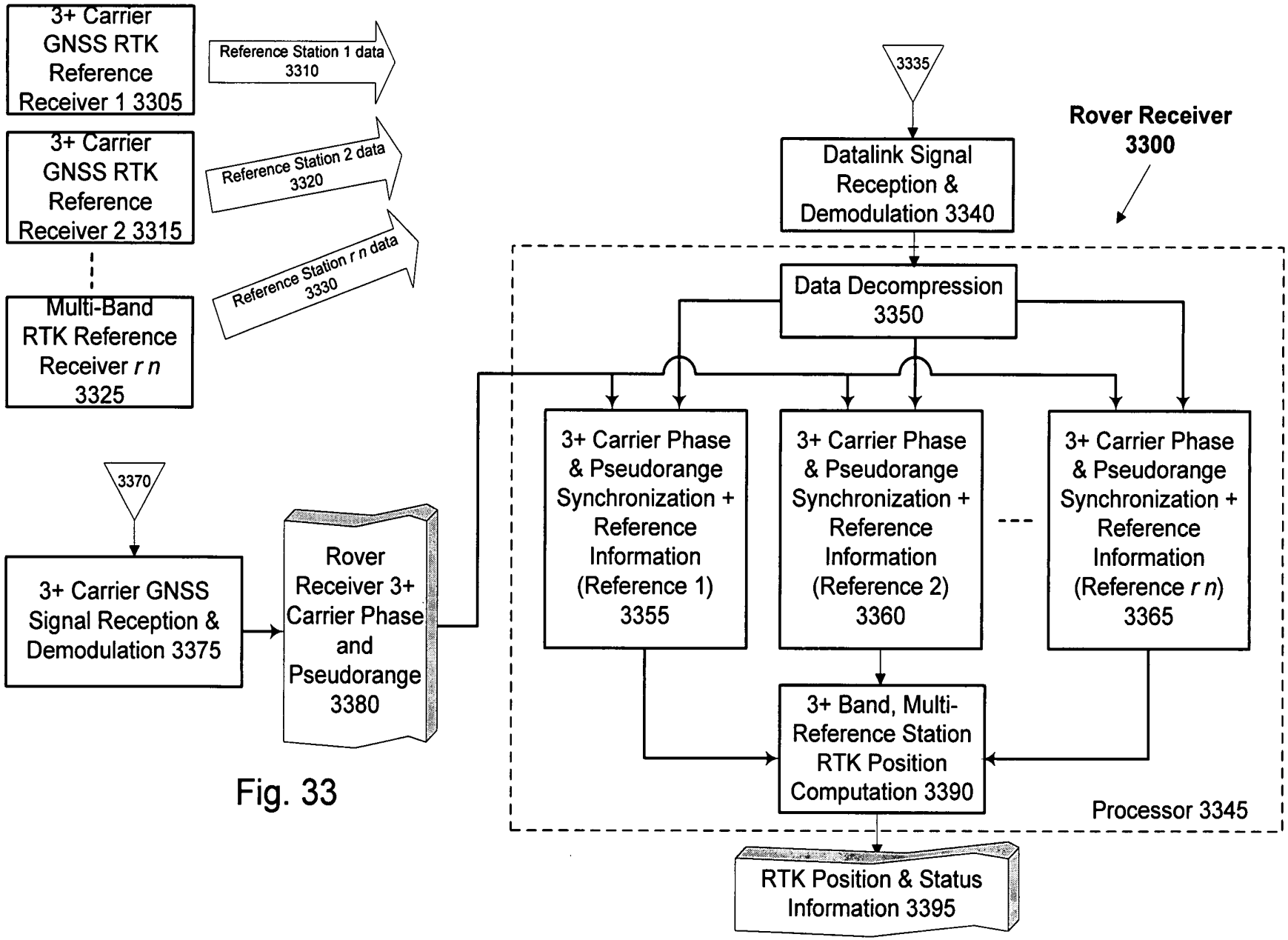

3+ Carrier GNSS RTK Reference Receiver 1 3305
Reference Station 1 data 3310
3+ Carrier GNSS RTK Reference Receiver 2 3315
Reference Station 2 data 3320
Multi-Band RTK Reference Receiver r n 3325
Reference Station r n data 3330
3335
Rover Receiver 3300
Datalink Signal Reception & Demodulation 3340
Data Decompression 3350
3+ Carrier Phase & Pseudorange Synchronization + Reference Information (Reference 1) 3355
3+ Carrier Phase & Pseudorange Synchronization + Reference Information (Reference 2) 3360
3+ Carrier Phase & Pseudorange Synchronization + Reference Information (Reference r n) 3365
3370
3+ Carrier GNSS Signal Reception & Demodulation 3375
Rover Receiver 3+ Carrier Phase and Pseudorange 3380
3+ Band, Multi-Reference Station RTK Position Computation 3390
Processor 3345
RTK Position & Status Information 3395

Fig. 33

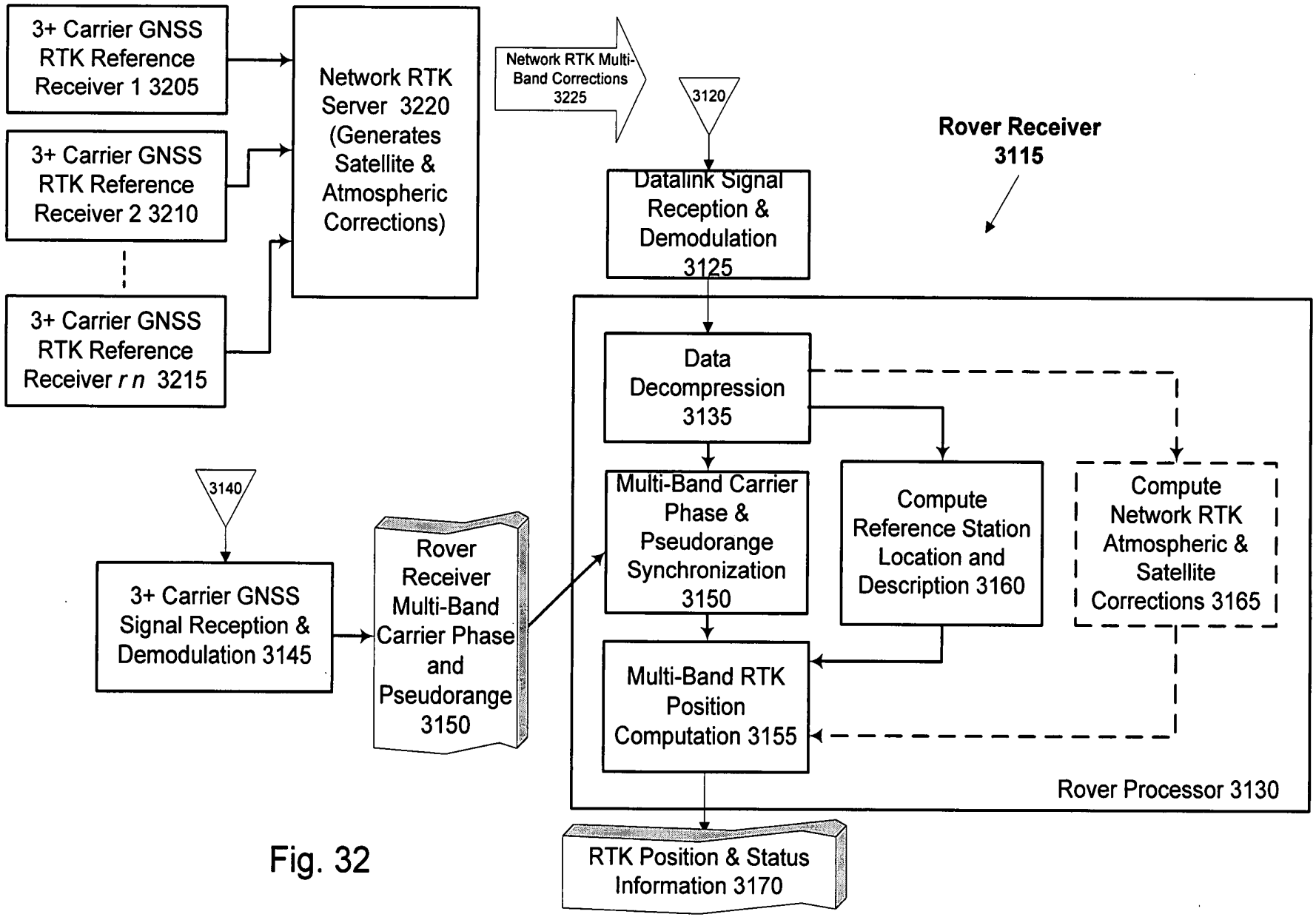

3+ Carrier GNSS RTK Reference Receiver 1 3205
3+ Carrier GNSS RTK Reference Receiver 2 3210
3+ Carrier GNSS RTK Reference Receiver r n 3215
Network RTK Server 3220 (Generates Satellite & Atmospheric Corrections)
Network RTK Multi-Band Corrections 3225
3120
Rover Receiver 3115
Datalink Signal Reception & Demodulation 3125
Data Decompression 3135
Multi-Band Carrier Phase & Pseudorange Synchronization 3150
Compute Reference Station Location and Description 3160
Compute Network RTK Atmospheric & Satellite Corrections 3165
Multi-Band RTK Position Computation 3155
Rover Processor 3130
3140
3+ Carrier GNSS Signal Reception & Demodulation 3145
Rover Receiver Multi-Band Carrier Phase and Pseudorange 3150
RTK Position & Status Information 3170

Fig. 32

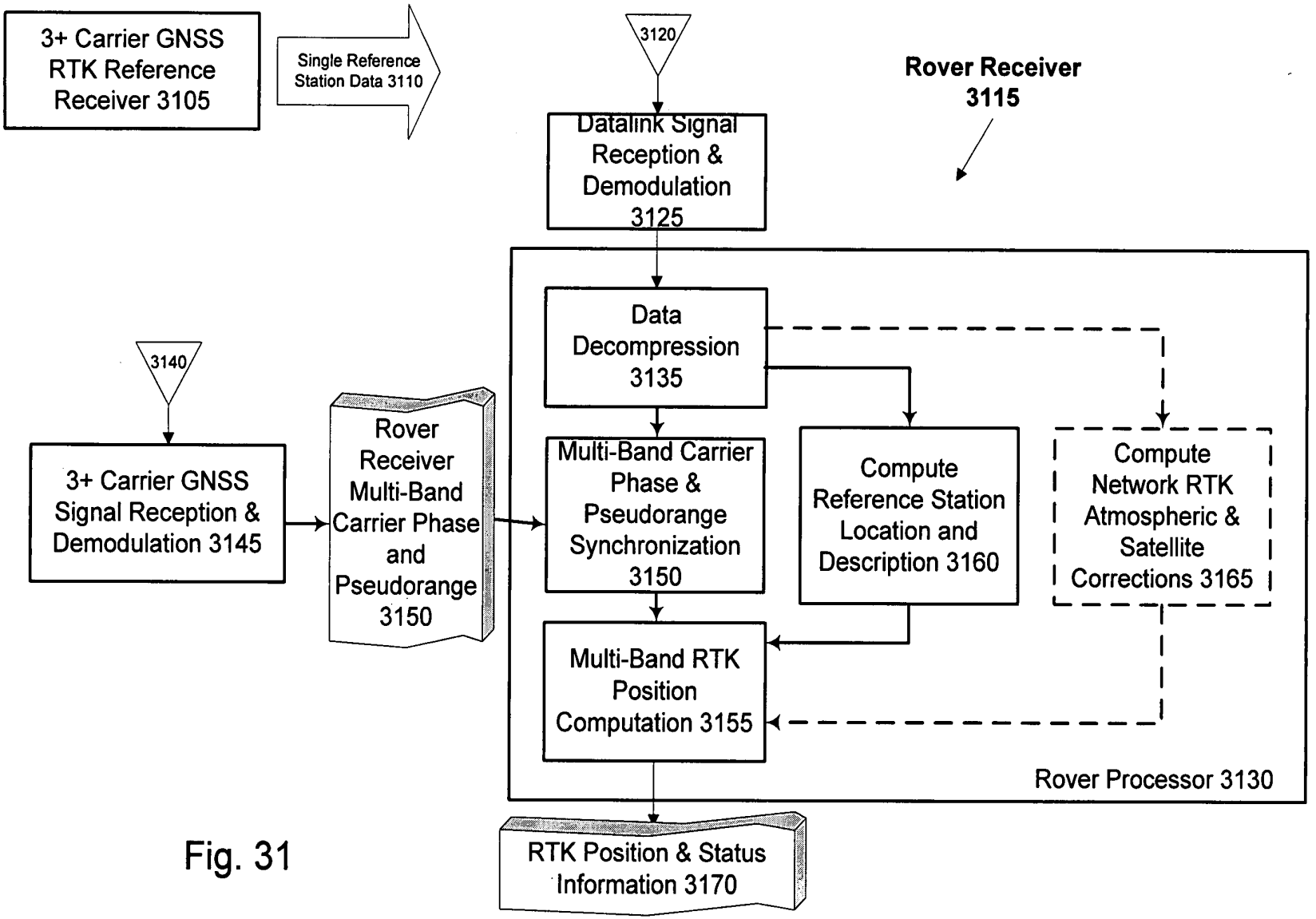

3+ Carrier GNSS RTK Reference Receiver 3105
Single Reference Station Data 3110
3120
Rover Receiver 3115
Datalink Signal Reception & Demodulation 3125
Data Decompression 3135
3140
3+ Carrier GNSS Signal Reception & Demodulation 3145
Rover Receiver Multi-Band Carrier Phase and Pseudorange 3150
Multi-Band Carrier Phase & Pseudorange Synchronization 3150
Compute Reference Station Location and Description 3160
Compute Network RTK Atmospheric & Satellite Corrections 3165
Multi-Band RTK Position Computation 3155
Rover Processor 3130
RTK Position & Status Information 3170

Fig. 31

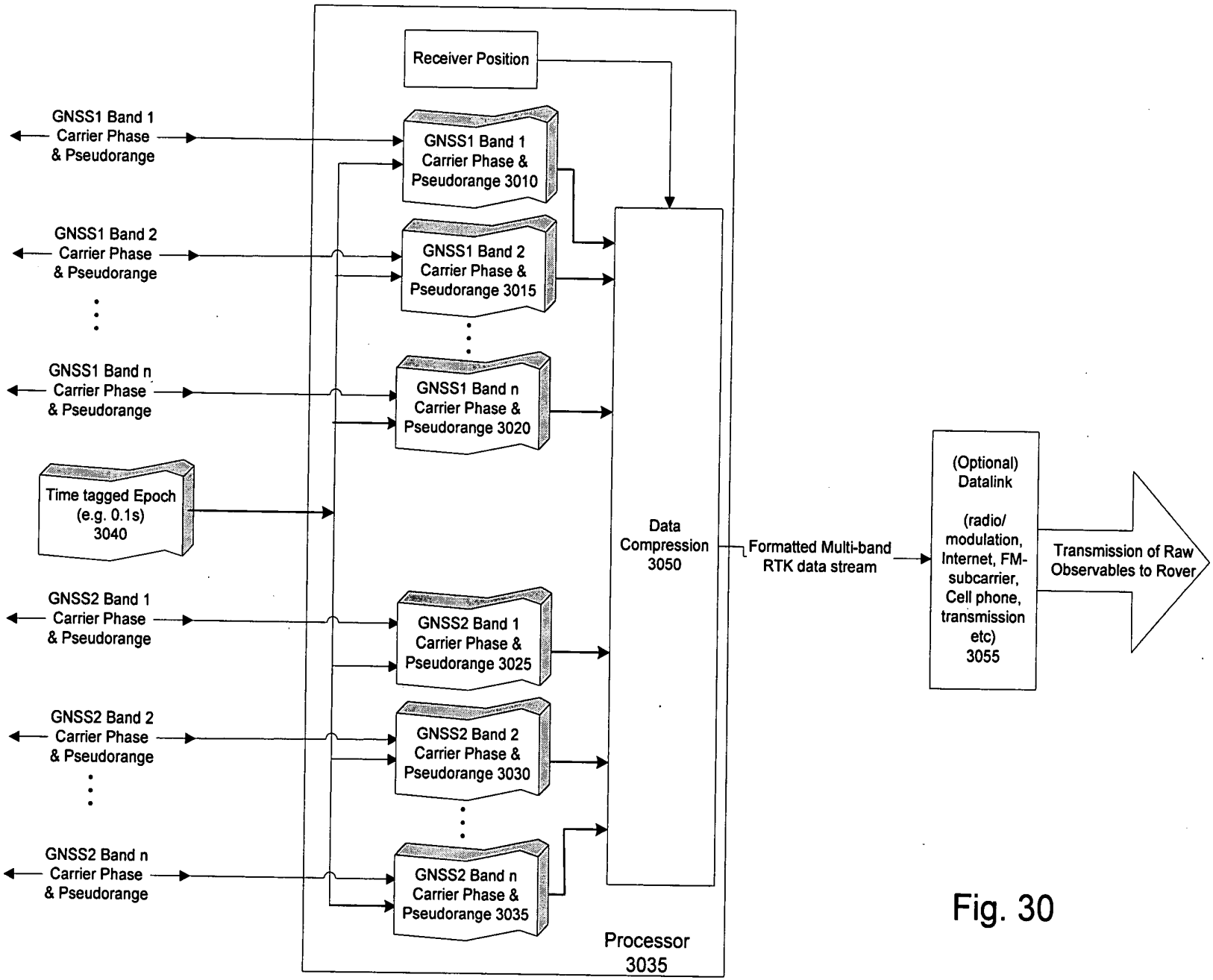

Receiver Position
GNSS1 Band 1 Carrier Phase & Pseudorange
GNSS1 Band 1 Carrier Phase & Pseudorange 3010
GNSS1 Band 2 Carrier Phase & Pseudorange
GNSS1 Band 2 Carrier Phase & Pseudorange 3015
GNSS1 Band n Carrier Phase & Pseudorange
GNSS1 Band n Carrier Phase & Pseudorange 3020
Time tagged Epoch (e.g. 0.1s) 3040
Data Compression 3050
Formatted Multi-band RTK data stream
(Optional) Datalink (radio/ modulation, Internet, FM-subcarrier, Cell phone, transmission etc) 3055
Transmission of Raw Observables to Rover
GNSS2 Band 1 Carrier Phase & Pseudorange
GNSS2 Band 1 Carrier Phase & Pseudorange 3025
GNSS2 Band 2 Carrier Phase & Pseudorange
GNSS2 Band 2 Carrier Phase & Pseudorange 3030
GNSS2 Band n Carrier Phase & Pseudorange
GNSS2 Band n Carrier Phase & Pseudorange 3035
Processor 3035

Fig. 30